SPEECHES

OF

THE HONOURABLE

MR. G. K. GOKHALE, C.I.E.

Non-official Member of the Viceroy's Legislative Council

WITH AN INTRODUCTION

AND A FRONTISPIECE.

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G. K. GOKHALE.

PREFACE

The author's justification for writing on this subject is that hand-loom weaving occupies a prominent place amongst the industries of this country. Not long ago the notion prevailed that it was an insignificant craft, rapidly dying out. But in the spring of last year, when the eyes of the Indian people were opened to the necessity of industrial development, the cry for hand-weaving was raised on every side. Investigations were made in the industry and it was discovered that, though gradually declining, its outturn amounted to nearly three times as much as that of the power-looms of India and that the possibilities of its development were very great. These revelations elicited opinions from different industrial thinkers in this country of a very conflicting nature. Some held the view that, though possessed of much vitality, it was useless to restore the industry as it would gradually die out in its struggle against the power-loom; while others urged that it was impossible to speak with any certain voice of the ultimate fate of any industry, and that there was no reason why our hand-weaving, which had with its most primitive systems of manufacture survived the competition of the power industry for 120 years, should not, if renovated, make a further stand against it for many years to come. It was further shown that the extraordinary vitality of the industry, which had hitherto been unintelligible, was

due to the great durability of the hand fabric which formed as powerful a factor in competition as the low price of the machine product. These arguments appeared to convert the detractors of hand-weaving to a certain extent, none the less they contended that mechanical science was making such rapid strides in the present age that the power-loom would some day outstrip the hand-loom. The controversy was then brought to a close by the explanation that any mechanical improvement in weaving would apply to power-looms as well as to hand-looms. The position and prospects of hand-weaving being thus discussed, popular opinion in the country, as far as it has been possible to judge, was in favour of its development. It may be observed, that the popular view coincides with what appears to be the settled policy of the Government of India with regard to this industry. But on what lines we should now proceed and how we propose to attain success can best be determined by considering suggestions from the several experts in the country. How the writer is striving towards progress in this direction will presently appear.

It is needless to mention that a knowledge of hand-loom weaving must first be diffused. The present treatise has therefore been written with the object of instructing its students in the principles of the art, of acquainting them with the methods practised in the industry here, and of suggesting to them certain improvements which the writer has, in conjunction with several hand-loom weavers, found most suitable for the country. In taking up this arduous task he has been able to deal with only the most urgent and immediate reforms but has every desire to

continue the work as further facilities present themselves. It was not desirable at this initial stage to get beyond plain weaving, nor did the class of fabrics generally consumed in India warrant such a step. The knowledge however, imparted herein is a theoretical study, a practice of the art is also necessary before the student may expect to profit by it. The latter can only be obtained by an apprenticeship with efficient weavers or a training at a weaving school. It therefore becomes evident that for a regeneration of the industry, technological institutes have become an imperative necessity. The Government and the philanthropists of the country are giving this question their serious consideration and it is expected that these institutions will soon be founded in different provinces. Having studied this treatise carefully and worked with competent weavers for a little time, it is certain that an intelligent and determined recruit would, with the improved methods, make hand-weaving a lucrative occupation. It is necessary that this fact should be impressed on the minds of our slow and timid people so that they may be roused to immediate action. They should not forget that with the existing methods the weavers are earning a fair livelihood, so much so that in Bengal it is difficult at present to obtain their services. How much better would not their prospects be with systems which would considerably lower the cost of production? An idea of this may be obtained from estimates given at the end of the book, the first two of which are taken from regular workers in the industry. It is therefore expected that a large number of people will now take to hand-weaving. When a certain number of efficient recruits join the

industry, there is reason to believe that its regeneration will be worked out through them. The weaver class who cannot at present accept the improved methods through their ignorance or conservatism, seeing the prosperity of the new-comers and to a certain extent driven by competition from them, will gradually adopt these methods as well.

It is time for those desiring the welfare of this country to realise that there is no other industry in India where the outlay needed is so small, where the sale of the product is so certain and in which, with efficient working, the profit is so assured. If, therefore, despite these circumstances, an earnest and determined effort is not made to push and expand this industry, what hope is there for larger industrial undertakings? A good number of quondam weavers are returning to their former occupation, but every facility must now be given to new people to enter its ranks.

CALCUTTA,
15th October, 1906.

H. H. G.

PUBLISHERS' NOTE.

The publishers desire to express their thanks to the Hon. Mr. Gokhale for his kind permission to bring out this publication. It is the first collection of his speeches and may claim to be fairly exhaustive, no important pronouncement of his having been omitted. The book contains four parts and an appendix. The first part includes all his utterances in the Supreme Legislative Council and in the Bombay Legislative Council; the second, all his Congress speeches, including his presidential address at Benares; the third, speeches in appreciation of Hume, Naoroji, Ranade, Mehta and Bonnerjee; the fourth, miscellaneous speeches delivered in England and India. The appendix contains the full text of his evidence both in chief and in cross-examination before the Welby Commission and various papers. These cover nearly a quarter of a century of a most strenuous, selfless and active public life and embrace the whole range of topics that have engaged and are still engaging the attention of the public. Full of instruction on every point and breathing in every line the moral fervour which is Mr. Gokhale's supreme characteristic, this volume, the publishers venture to hope, will command wide popularity.

The publishers would take this opportunity to thank Mr. V. S. Srinivasa Sastri for the great help rendered by him in passing this volume through the press and for the valuable assistance he has been always giving them in the preparation of several of their publications.

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INTRODUCTION

THE present time in India is full of portents. One never opens the day's newspaper without anxiety. Strange but powerful ideas have found lodgment in men's minds. The air is thick with shadowy visions of the future, fantastic plans, harrowing doubts, black designs, born of blind hope or unreasoning despair. Political postulates, hitherto accepted without question, are freely challenged. The very foundations of our public life are being torn up aud examined. A feeling of intense uneasiness broods over the land, and the more susceptible spirits cry in anguish that they have been the victims of foul treachery.

A friendly and comforting voice at such a juncture must have eager attention. To those whose minds have not been unhinged by the misfortunes of the time, the speeches of the Hon. Mr. Gokhale are certain to bring relief and strength. Alarmed by the distracted cries of quacks, the public will be glad to listen to the calm counsel of one who has made public ills his special study. Keenly alive to every element of the situation, Mr. Gokhale, as will appear from the contents of this volume, bids us be of good cheer, advises no violent wrench from the past, and strongly deprecates violent remedies and desperate suggestions.

The Maharashtra Brahman, whom Mr. Gokhale represents at his best, is no favourite with Anglo-India. We all know his caricature by the *Pioneer*. Wiles, restless intrigue, and elusiveness are represented to be his strong points, while his political capacity is limited to the sphere of destruction. Amongst the last people in India to pass under the direct rule of the British, it is no wonder that he retains lively memories of Peshwa domination and exhibits the acutest political instincts of all races in India. In other parts of the country one may find large numbers of educated men in whose lives politics is of feeble interest at normal times, and but one of several powerful interests at abnormal times. With the Poona Brahman, politics is ever a passion, and it does not take much to raise the passion to a white heat. He readily sees the precise bearing and import of governmental measures, and, if his inferences as to motive be marked by suspiciousness, it is not altogether his fault. He is excelled in imagination, susceptibility, and even in the higher qualities of the intellect by the Bengalee; in keenness of grasp, clearness of vision, and sense of proportion the Madrassi is quite his match, if not more; but for vigour of mind, dogged persistence, and capacity for practical work, he is certainly unrivalled. The Maratha supremacy, short-lived as it was, is an eloquent witness to the constructive capacity of the race, and Poona boasts at the present day of more

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HAND-LOOM WEAVING.

CHAPTER I.

INTRODUCTORY.

India is the classic land of the art of weaving the origin of which dates back to some thousands of years. We find mention of this industry in the Bible with reference to periods between fifteen and seventeen hundred years before the birth of Christ, in the Book of Job, vii., 6, and in the Book of Exodus, xxxv, 25. Indeed, there can be little doubt that weaving is a very ancient craft. The historian Thornton referring to the ancient civilization of India relates—"Ere yet the Pyramids looked down upon the valley of the Nile—when Greece and Italy, those cradles of European civilization, nursed only the tenants of the wilderness—India was the seat of wealth and grandeur. A busy population had covered the land with the marks of its industry; rich crops of the most coveted productions of nature annually rewarded

the toil of the husbandman; skilful artisans converted the rude produce of the soil into *fabrics of unrivalled delicacy and beauty;* and architects and sculptors joined in constructing works, the solidity of which has not, in some instances, been overcome by the revolution of thousands of years. The princes and nobles of India, unlike the wandering chieftains of the neighbouring countries, already dwelt in splendid palaces, and clothed in the gorgeous products of its *looms*, and glittering with gold and gems, indulged in a corresponding luxury in every act and habit of their lives."*

Schulze-Gaevernitz, speaking on the cotton-trade of Europe, states that "India, the ancient seat of trade, is also the home of the cotton industry. Alexander the Great found even in his time the natives clothed in cotton garments. Indian woven goods have been from ancient times imported into Europe as articles of luxury."† John Watson, cotton manufacturer and author of several works on cotton spinning and weaving, complains bitterly of the decadence of the industry in India. He says that—"The Hindoos and Egyptians have been acquainted with weaving for thousands of years, and it is well known that the fabrics

* Thornton's "History of British India," Vol. I. p. 3.

† Schulze-Gaevernitz's "The Cotton Trade in England and on the Continent," p. 19.

made in India were much valued and yet they have made little or no improvement in their looms, although it appears that looms were originally invented in the East."* It is thus possible to pursue the history of the craft through the records of remote antiquity and perhaps definitely trace its origin to India. The only other country where weaving was known in the early ages was Egypt, but the one writer up to now that appears to make the Egyptian a rival claimant with the Hindoo in the invention of this most useful art, also prefers the claim of the latter. Moreover, we have it on the authority of a historian, that while yet the artisan had not manifested himself in Egypt, India was unrivalled in its fabrics. India may, therefore, justly claim to be the birth-place of the weaving industry.

The American writer Posselt, an authority on the art of weaving, describes the spread of the industry thus—"Of the four great staples which provide us with clothing (cotton, silk, wool and flax) cotton, now the cheapest and most indispensable, was last to come into general use, although thousands of years before it was the national cloth of India, the same as linen was of Egypt. The Chinese who had known the cotton plant from

* Watson's "Art of Weaving," p. 15.

the earliest times began its manufacture into cloth during the thirteenth century. The earliest explorers of this continent found beautiful fabrics of cotton among the natives of Mexico and South America. In the fourteenth century (long after linens, woollens and silks had become articles of commerce), cottons were introduced into Europe."* In 1733 the elder Kay of Bury invented the fly-shuttle which was shortly after introduced in England thus giving an impetus to the weaving industry of his country. Hitherto, Indian fabrics were largely used in Europe, now England entered into competition with India. In 1760 the younger Kay constructed the 'drop-box' and applied it to English looms which facilitated the production of 'coloured mixtures.' But the greatest achievements of mechanical genius were on the threshold of this industrial epoch. The invention of the 'spinning-jenny' by Hargreaves in 1764, of the 'water-frame' by Arkwright in 1769 and of the 'mule-jenny' by Crompton in 1779 wrought an enormous change on the destiny of the cotton manufacture. Previous to this, there existed the hand-spindle and a comparative scarcity of yarn, now there began to be produced an abundance of it. To use up this larger production, faster looms became necessary.

* Posselt's "Cotton Manufacturing," Part I, Introduction.

About this period and probably during the days of Warren Hastings, the fly-shuttle was introduced in Serampore by the Danish settlers of the town, but political causes prevented the spread of the improvement in this country. In 1785 Dr. Cartwright devised in England the first power-loom. Other machinists followed up his patent with developments, nevertheless, for over fifty years the power-loom was not an economic success. It could not be worked much faster than the hand-loom as it had to be frequently stopped owing to the breakage and exhaustion of weft. So hand-looms continued to work along with power-looms. Certain legislative enactments then followed which handicapped India to a certain extent in her competition with England. In 1841, Bullough and Kenworthy invented the 'weft-fork' for automatically stopping the power-loom on the breakage or finish of weft thus rendering it possible to be worked much faster than the hand-loom. This dealt a very severe blow to the hand-loom in England and also affected the industry here being then, as to this day, in a very backward condition without the advantage of even the fly-shuttle. The advent of the power-loom in Bombay in 1854 brought a new rival to the hand-loom in this country. But neither the utmost efforts of mechanical genius as

exemplified by the power-loom in England and in India, nor the many impediments put in the way of the hand weaver, with the disabilities he has suffered from during the last century and a half have been able to kill the hand-loom industry of this country.

CHAPTER II.

THE PRINCIPLES OF WEAVING.

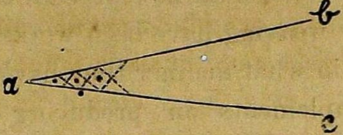
Weaving is the art of setting in a flat form two series of threads at right angles to each other, each thread of the one series being passed under and over the threads of the other alternately. Mr. Thos. W. Fox, Chief Lecturer in the Municipal Textile School at Manchester defines the method thus—"Weaving consists in interlacing two sets of threads one placed longitudinally and the other transversely in a fabric."* The longitudinal threads of a fabric are called the *warp* threads sometimes referred to collectively as the warp, and the transverse threads of a fabric are called the *weft* threads which are returned at the edges making what is termed a *selvage* (or self-edge).

If a woven fabric be critically examined it will be observed that the transverse threads go over and under the longitudinal threads and *vice versa*. If the loom were not in existence, the fabric would have to be woven by placing the longitudinal threads in one direction and passing

* Fox's "The Mechanism of Weaving," p. 3.

at right angles to them, each transverse thread over and under each longitudinal thread precisely in the way that a housewife would put a patch on an old coat. Now, if a large piece of cloth had to be woven in this manner, what an amount of labour it would entail? But if the longitudinal threads could be divided into two halves—one half containing the alternate threads of even numbers and the other half containing the alternate threads of odd numbers—and the former half raised while the latter half were lowered, then a transverse thread put in between the two halves, next the position of the two halves reversed and another transverse thread put in, and so on, how much simpler would the operation be? This notion was probably conceived in the mind of the unknown inventor of the art thousands of years ago and has ~~since~~ formed the principle upon which weaving is based. To manipulate these threads, however, in the aforesaid manner certain implements were necessary. These implements were gradually devised and being set together formed a machine called the loom. Thus the principles of the art were first conceived and the practice of it then followed. In a loom the process of weaving is consequently based on the foregoing principle as we shall presently see. Several longi-

tudinal threads are taken, say 100 in number. Half the alternate threads (containing the second, the fourth, the sixth up to the hundredth thread) the side section of which is represented by *ab* in the diagram, are raised; and the other half (containing the first, the third, the fifth up to the ninety-ninth thread) represented in their side section by *ac* in the diagram, are lowered. This separation of longitudinal threads is called 'shedding.' A transverse thread is then placed between *ab* and *ac* at their opening, known as the act of 'picking,' and sent in where *ab* and *ac* meet, this act being called 'beating-up.' The transverse thread is seen in its side section by the first point in the diagram. Next *ab* is lowered and *ac* raised and the transverse thread is thereby secured. Another transverse thread, represented in its side section by the second point in the diagram, is then put in between *ab* and *ac* in the aforesaid manner, and the positions of the alternate threads are again reversed, and so on. It must be carefully borne in mind that if the positions of the alternate threads of the warp were not reversed every time, there would be no binding up of the weft thread and consequently no weaving done.



Wherefore it will appear that in weaving there is not only an alternation in the warp threads but also in the weft threads. This is an action which weavers even do not always realise.

We shall now proceed to see how the principles of weaving have been worked out in the loom, that is in what manner they have been applied to certain implements in producing cloth. We have just seen that there are three primary motions in a loom during the process of weaving known as *Shedding*, *Picking* and *Beating-up*. These motions are effected by the movement of certain parts of the loom called the *healds*, the *shuttle* and the *slay* respectively.

Shedding is the separation of the alternate threads of the warp thus making a space for the shuttle carrying the weft thread to pass through. This separation is caused by the elevation and depression of the healds.

Healds or heddles are parallel double strings with centre loops or eyes through which are drawn the alternate threads of the warp. The strings are made of either silk, cotton or gut, and are bound at both ends to two wooden laths which lie parallel to each other about six inches apart. The loop is formed of the material used in the heald, but the eye consists of a hole through a small piece of steel

or glass, flat and oblong in shape, fixed at the middle of the heald and called the 'heald-mail.' It is so called because it carries the warp thread. Generally from 500 to 1200 of these healds, according to the width or fineness of the cloth to be woven, are tied to the two laths and thus constitute what is termed a 'leaf or shaft of healds'. A number of these shafts of healds used in a loom are called a 'set of healds'.

The shuttle is a small wooden boat-like implement which carries the weft thread across the warp.

Picking is the throwing in of the shuttle carrying the weft thread through the shed or division in the warp. For this purpose the weft thread is wound on a pirn which is put inside the shuttle and the end of the thread is taken out through the eye of the shuttle. The threaded shuttle is then sent through the shed. During its transit, the weft thread is unwound from the pirn and left behind in the track of the shuttle.

The 'pirn' or cop is a small wooden taper on which is wound the weft thread. The tapering end facilitates the unwinding of the thread.

Beating up consists in beating the weft which has passed through the warp up to the web so that after each pick the weft thread left by the shuttle becomes part of the cloth. This is performed by

what is termed the 'slay' which contains the reed that comes in contact with the weft.

The Slay or Lay or Lathe is a rectangular frame consisting of a top or bottom beam, side bars called 'swords' and two battens at the top or bottom between which is fixed the reed and at the ends of which are fitted two shuttle-boxes. In the Indian loom, the beam is at the top and the battens are at the bottom so that the lay is pendant from the top frame of the loom. But in the Japanese and English looms, the positions are just the reverse so that the slay rests on hinges at the bottom frame of the loom. The slay is rocked to and fro. It is moved away from the cloth when the shed opens to allow the shuttle to pass through and moved towards the cloth with a slight blow to beat up the weft.

The Reed is a long, narrow, comb-like implement having dents or teeth between which pass the warp threads. The functions of the reed are to beat up the weft thread and to keep the warp threads equidistant to each other. The space, therefore, between the warp threads is determined by the dents in the reed; the closer the dents the finer the weaving and the wider the dents the coarser the weaving. The surface of the lower batten sloping towards the reed forms the 'shuttle-race'. This

surface is made slanting to be in accordance with the form of the shed, but the slope also prevents the shuttle from running out.

Reedspace is the space occupied by the reed in a loom. The width of a loom is designated by its reedspace.

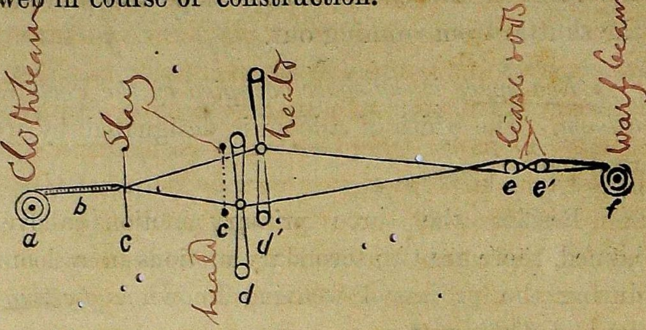
Besides the three primary motions abovenamed, there are two secondary motions in a loom during the process of weaving known as *Letting-off* and *Taking-up*.

Letting-off consists in unwinding the warp-beam and letting out the warp as the cloth is being woven. The warp-beam is a wooden roller at the back of a loom which supplies the warp threads for the weaving operation.

Taking-up consists in winding up the cloth on the cloth-beam as it is being woven and in regulating the speed of the winding, thus determining the space between the weft threads. The cloth-beam is a wooden roller in front of a loom on which is wrapped the cloth that is woven. These two motions are however the result of one movement, namely the passage of the yarn from the warp-beam as threads to the cloth-beam as a woven fabric.

To explain more clearly how the principles of weaving have been applied in the loom, a diagram

is given below showing the side section of a plain web in course of construction.



From *f* the warp-beam, the warp threads pass on to *e′e* the lease-rods where the alternate threads are divided and crossed. They are then formed into a shed by the elevation and depression of the healds *d′d*. As the shed is formed, the slay comes up to the right-side *c*, receives the weft thread and beats it up to the left-side *c*. The threads are then formed into a web and pass on to the woven cloth at *b* which is finally wound up at *a* the cloth-beam. The dotted line *c* shows the reed in the slay at the shedding and picking motions, and the plain line *c* shows it at the beating-up motion. To keep the warp threads distinct from each other and so prevent their entangling, a 'lease' is formed between *e* and *e′*. *A lease is the crossing of a series of threads with another, the threads of the one series being passed along the threads of the*

other alternately. The two series are thereby divided. In the above diagram, the side section of a lease is shown. The lease plays an important part in weaving and it will be seen later on, how necessary it is in the warping and looming of yarn. It may be noted here that in a loom, the warp threads are kept stretched out by the tension on them from the warp and cloth beams. But at the weaving operation, the weft thread is depressed at equal intervals along its length by the reversing action of the shed and assumes the form of a wave. When the weft is pulled by the next pick, the warp threads then assume the form of a wave. There is thus a mutual giving away at equal intervals in the warp and weft threads which attain a partially waved form in the web. This accounts for the contraction which takes place in the threads when a cloth is woven. The position of the warp is not the same in every loom. In the Japanese and English looms the warp threads from the warp-beam pass over a wooden roller called the back-rail and then through the healds and the reed; after that, they are woven into cloth which passes over a front rod called the breast-beam and then goes on to the cloth-beam. In the Indian loom there is no back-rail nor breast-beam and the warp is mounted as shown in the above diagram.

Besides the five motions of the loom above-named, there are some minor movements called the 'auxilliary motions' connected with shedding principally, a knowledge of which is not essential to the plain weaver. Weaving is divided into two principal classes—plain or simple weaving and fancy or complex weaving. A web whether simple or complex arises out of the order in which the warp threads are separated to receive the weft. The essential difference between the two classes of weaving is that, in the plain web the warp and weft threads are interlaced alternately but taken one thread at a time, whereas in the fancy web this interlacing is alternate being at regular intervals, but with more than one warp thread at a time. There are, however, exceptions to these two general systems of weaving. At the present day, there is almost an infinite variety of webs formed on the loom. The most extensive portion of this study relates to fancy weaving which is subdivided into the three main heads—twill, leno and figure work. The fancy web is obtained by the formation of various sheds in the warp by the use of several shafts of healds and by the variety of manner in which the threads of the warp are drawn through these healds. 'Coloured mixtures,' such as stripes and checks, form also a portion of this art. These

are obtained by the use of coloured threads in the warp or weft and sometimes in both of them. When different colours are required in the warp, they are arranged in it during the warping process, but when they are required in the weft, several shuttles containing weft thread of different colours are used. This is done by means of the drop or revolving box in place of the ordinary shuttle-box. Coloured mixtures may, however, be prepared both in plain and fancy webs. The foregoing lines constitute the principal varieties of the cotton web.

CHAPTER III.

DESCRIPTION AND WORKING OF LOOMS.

Speaking of the origin of cotton weaving, Richard Marsden one of the greatest authorities on this subject states that "the best historical evidence obtainable points to India as the birthplace of cotton manufacturing."* But all trace of the inventor of this art or of the period at which it began have apparently been lost by the distance of time. Our earliest notion of weaving in this country was when it attained a certain stage of development. This advanced state of the industry is alluded to by Manu the great Hindu lawgiver in his Institutes and is spoken of by the eminent English historian Thornton with reference to a period before the civilization of Egypt. Weaving was however known in the early ages in Egypt and Assyria and at a later period in Persia, Greece and Rome. The earliest looms used in Egypt and Greece are described by modern writers† as having been vertical in shape but in India they were horizontal as at the present day.

* Marsden's "Cotton Weaving" p. 1.

† Dr. Andrew Ure in his "History of the Cotton Manufacture" and Alfred Barlow in his "History of Weaving."

The Egyptian loom of which the Grecian was probably an imitation consisted merely of an oblong frame standing upright in the direction of its length along which the warp was arranged. The weft was put in by means of a stick, the operation beginning from the bottom of the warp and going upwards. The cloth was thus woven in a vertical position in the Egyptian and Grecian looms. The Indian loom consisted of two beams resting on pegs in the ground between which the warp was extended. The loom therefore represented an oblong figure, the length of which ran from beam to beam. On either side the warp was a post at the top of which was mounted a rod. From this rod were suspended the leaves of healds which were connected to the toes of the weaver sitting before the front beam. He shedded the warp by working the heddles up and down with his legs and passed the weft from side to side with a stick. The cloth was thus woven in a horizontal plane. As far as we are aware, the reed and the shuttle were then unknown to the Indian weaver. They evidently came into existence and were adopted by him at a later period. In course of centuries, the horizontal loom with the healds, the reed and the shuttle were also adopted in countries bordering on the Mediterranean. The periods at which these

different developments in the loom took place in these countries is not known. The literature on weaving really commenced from about the 16th century or only about 400 years ago. About this period accounts written of looms in European countries show that they were greatly improved. The English and French looms were then mounted in a rectangular frame like the old Indian loom that may be seen here up to this day. These three looms were therefore constructed on more or less the same plan and differed from each other in some of their minor parts only. A detailed description of each loom need not be given here as nothing unknown to us could be learnt from them. The present flyshuttle loom embodies the few points of utility that they contained. But an idea of these looms may be gleaned from the following sketch. The looms were, as just stated, mounted in a rectangular frame. The weaver sat in front of the cloth beam, the yarn being arranged between it and the warp beam a few feet ahead. The shafts of healds depended from a top bar across the loom by means of cords running round pulleys. These shafts were connected by strings again to two treadles fixed at the bottom of the loom. The reed was carried in a lay pendant from the top of the loom. The shuttle was thrown along the lay

from hand to hand. The weaver shedded the warp by means of the treadles with his feet. He next threw the shuttle with one hand and received it with the other. Then he beat up the weft and with all these movements completed only one pick in the web. Moreover, if the cloth he was weaving were wider than the stretch of his arms, another operator was required at one side of the loom to receive the shuttle and throw it back. These looms naturally required great labour and skill to manipulate yet worked very slowly.

In 1733 John Kay a woollen manufacturer of Bury in Lancashire invented the fly-shuttle and applied it to the loom. His invention consisted of an improved arrangement for picking. He placed a box at either end of the lay for the reception of the shuttle. In each of these two shuttle boxes an iron rod or spindle extending the whole length of the box was fitted and a shuttle-driver called the 'picker' slided through the spindle. The two pickers were attached to each other by a string slung before the lay. In the centre of the string was a handle by which the shuttle was jerked from one box to the other. In the older looms, we have just seen that the picking had to be done by the use of both hands, or in the case of wide cloths by the help of a second operator;

here the use of one hand alone jerking the handle to and fro served the same purpose. This invention though a simple one created quite a change in the industry, for it rendered the process of weaving less laborious and more expeditious. The fly-shuttle attachment was naturally adopted by different countries in Europe and was introduced into India by the Danes in the latter part of the 18th century. The Indian flyshuttle loom corresponds almost in every detail to the structure of Kay's fly-shuttle loom except that the warp in his loom was extended in the direction of its length whereas in the former it is in the direction of its width. The Indian system is ofcourse an improvement, as less of the warp is subjected to a strain.

In 1760 John Kay's son Robert Kay invented the 'drop box,' an appliance for changing shuttles in the loom to enable the use of weft of several colours After this period, for many years the attention of inventors and machinists was directed to the construction of machines for spinning and weaving by steam power, as we have seen in the first chapter, and the hand loom was neglected. It was only during the last decade when England and certain European countries found that the power loom was no better than the hand loom in the

manufacture of certain class of cloths that the hand loom was again developed. The modern hand loom, which is constructed largely and by various manufacturers at the present day, is based entirely on the principle of the power loom although the latter itself had evolved from the old hand loom.

THE INDIAN FLY-SHUTTLE LOOM.

This loom is an improvement on the old Indian loom as already stated and is the only machine that the poverty-stricken weavers of the country are well able to afford. It is moreover a very simple machine, easily repairable and turns out, from the nature of its working, cloth that wears longer than the product of the power loom each weft in the fabric being put in with the utmost care. Owing to this virtue, if improved, it should be of service to weavers in the country for many years to come.

Description.

The loom is fitted into an upright rectangular frame. See Figure I which shows a front view of the loom. The lay (*docthee*) is suspended from the top of the loom by means of two small iron pins which project one on either side of the top bar H of the lay. These pins rest on grooves in

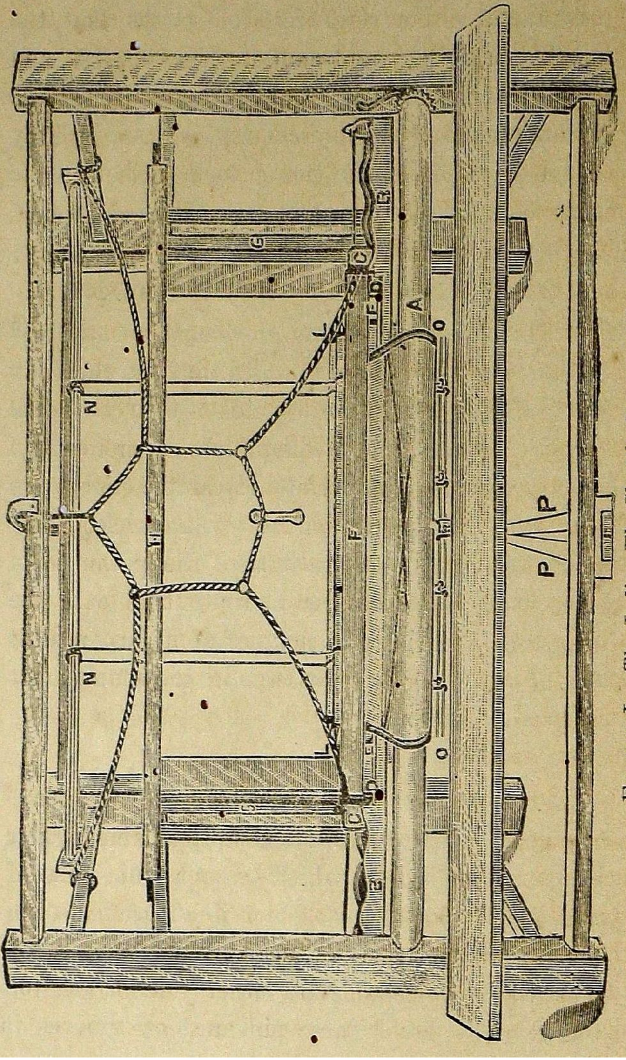


FIGURE I.—The Indian Fly-Shuttle Loom. (Front view).

cross-rails at either side of the loom so that the lay may swing backwards and forwards. GG are the swords of the lay. The lower portion of the lay carries the reed EE (*shanah*) and the shuttle-boxes BB. The reed is fitted into grooves cut in the upper and lower battens. On either end of the lower batten of the lay are the shuttle-boxes and the surface of the batten slanting towards the reed forms the shuttle-race DD. On this runs the shuttle (*makoo*) to and fro. To the top of each box is fitted an iron rod which runs through and guides a wooden block sliding along a groove at the bottom of the box. These blocks CC (*marrah*) form the pickers, that is, they do the picking in the loom by driving the shuttle. Along the top of the loom runs lengthwise a rope, the middle of which rests on a string hanging from above the loom. From the rope hang two strings which are connected to a handle at the centre and the two pickers on either side.

Along the top of the loom lengthwise is fixed a hexagonal roller from which hang two strings NN being wrapped round it. The ends of these strings are tied to two shafts of healds LL (*jhap*); the two ends in front to the front shaft and the two at the back to the rear shaft, so that if one shaft rises the other descends and *vice versa*.

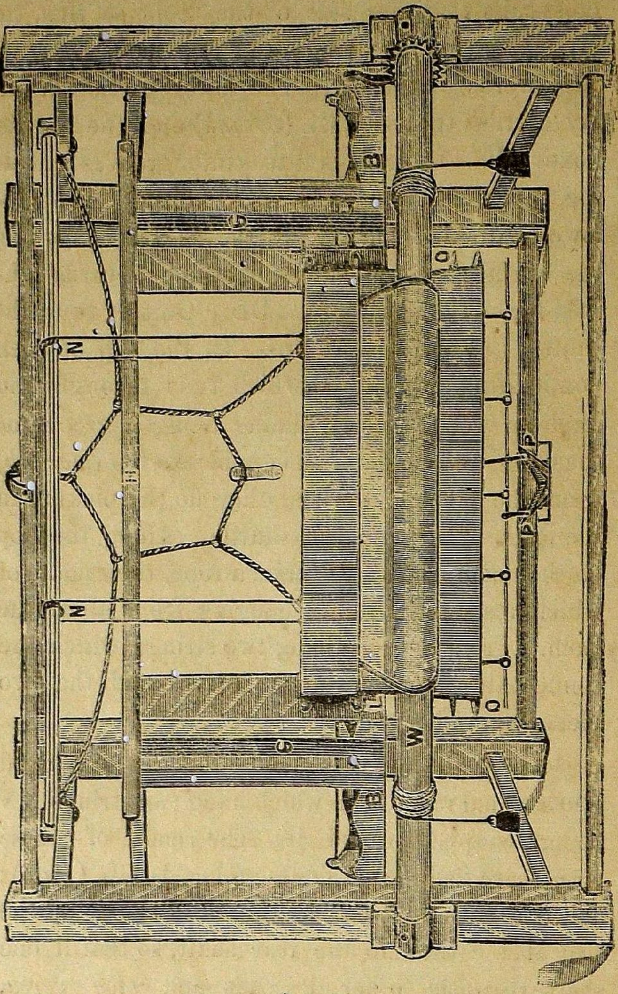


FIGURE II.—The Indian Fly-Shuttle Loom. (Back view).

This is an improvement on the old loom where in place of the roller there was a bamboo or a rod from which hung levers (*nutchnees*), or pulleys (*kopees*) three or more in number, from which again were suspended the two shafts of healds. In each lever or pulley one side string was attached to one heald-shaft and the other side string to the other heald-shaft. The difficulty about this old arrangement was that several levers or pulleys did not always act uniformly and consequently the healds would not work in a line. A single roller, however, always works uniformly and is therefore a better means of suspending the heald-shafts. If the heald-laths are made of flexible wood such as bamboo, three or more strings should suspend each shaft, but if they are made of some rigid wood, one string at either end would suffice. From each heald-shaft is hung a wooden rod. These two rods OO are tied to the two treadles PP which have their fulcrum at the front of the loom. The treadles work the healds up and down and thereby cause the *shedding motion.*

The *picking motion* is effected with one hand by jerking the handle to and fro and the *beating-up motion* is effected with the other by working the lay backwards and forwards holding it by its upper batten F. At the front of the

loom is the cloth-beam A. At one end of the cloth-beam is a thin toothed wheel against which is fixed a click which prevents the beam from unwinding. The winding which forms the taking-up motion in the loom has to be done by hand.

Figure II shows a back view of the loom. At the back of the loom is the warp-beam W. This beam is detachable for convenience of the beaming operation which will be explained in a subsequent chapter. The necks of the beam are of smaller diameter than that of its body and are put inside of two brackets fitted at opposite sides of the loom frame. The necks of the beam pass through openings in the brackets at *o* and *o* which are then closed up by wedges. Weights are suspended by ropes which are wound round the warp-beam in a direction opposite to that of the warp. These weights which should not be allowed to touch the ground, prevent the warp from unwinding except at the letting-off motion, yet they enable it to yield slightly at any undue strain thus minimising the breakage in warp threads. This system of weighting the warp-beam which has been in existence for many centuries in this country and has been adopted for almost every kind of loom in England cannot be improved upon easily. Recently certain loom-makers

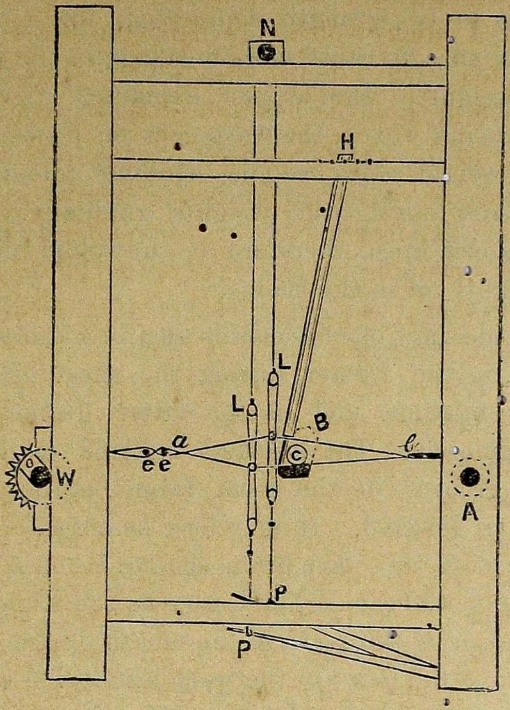


FIGURE III.

The Indian Fly-Shuttle Loom. (Side view).

Showing the shedding and picking motions.

here have been substituting a rigid beam held back by a click for this weighted beam. Such an innovation is to be strongly deprecated, for a rigid beam is sure to cause more breakage in the warp than a weighted beam as just explained. As the cloth is being woven, the warp goes on unwinding but the weight-ropes keep on winding round the beam thus raising the weights gradually. The weight-ropes must therefore be unwound before the weights touch the beam.

A side view of the loom is seen in Figures III and IV, in the former during the shedding and picking motions, and in the latter during the beating motion. The brackets referred to above run on grooves in the loom frame and can be raised or lowered. It may here be observed that in this loom the warp-beam should be on a level with the cloth-beam. The lease-rods are shown at *e* and *e*; *a* is the warp at the mouth of the front lease-rod, *b* the point in the warp last woven called the fell of the cloth. In fig. III, *ab* represents the shed open to receive the shuttle and in fig. IV, it shows the shed closed for the beating motion. The shed closes at the point when the alternate threads of the warp cross each other. In fig. III, *c* is the shuttle passing through the shed and in fig. IV, E is the reed in the slay beating up the

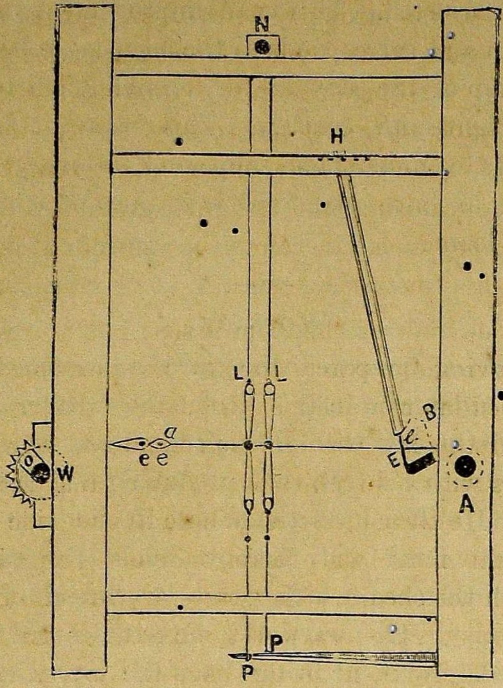


FIGURE IV.

The Indian Fly-Shuttle Loom. (Side view).

Showing the beating motion.

weft. The points shown in the cross-rails on either side of H are grooves along which the lay may be adjusted. This is an improvement on the old loom and corresponds to the adjustable bearing at the top of the slay in the French loom of the early eighteenth century. This loom, it is not difficult to understand, appeared in every other respect to have been an imitation of the old Indian loom.

Working.

Having prepared the yarn and loomed it as described later on in this book, the weaver sends forward the lay with his left hand and works the treadles with his feet, thus producing a shed in the warp. He then jerks the handle to one side with his right hand and thereby sends the shuttle through the shed which leaves a thread of weft in its track. He now works the treadles and closes the shed. Next, he brings back the lay with the weft thread in it to a few inches off the cloth-beam and secures the thread there by reversing the shed with the action of the treadles. He then takes back the lay, sends the shuttle through the reversed shed with the weft thread behind it, closes the shed, beats up the thread to the weft near the cloth-beam and produces a shed again. He conti-

nues these movements, rolling up the cloth every now and again, as it is being formed. All these operations constitute weaving in this loom. It must be clearly understood that the shed is produced, closed and reversed when the alternate threads of the warp respectively open, cross each other, and open again in the opposite direction. It will also be seen that in this loom, the shedding motion is effected by the feet, and the picking and beating motions by the two hands.

To keep the cloth to an exact width, that is, the length of weft taken into the fabric uniform throughout the piece, two sticks measuring slightly longer than the width of the fabric are joined together and fixed into the edges of the cloth by means of pins at their extremities. This stretches the cloth out to its proper width. The sticks then assume the form of a bow and are called in the vernacular the '*mothee.*' This also keeps in the selvage ends. The '*mothee*' serves the function that 'temples' do in power-looms. An appliance precisely the same as the '*mothee*' and known as the 'old hand-temple' was used for this purpose in English and French looms.

The speed of this loom is between 45 and 60 picks per minute depending on the condition of the warp and the skill of the weaver.

THE SAYAJEE COTTAGE LOOM.

This loom is really the Indian fly-shuttle loom with an attachment which combines the picking and beating-up motions. The attachment consists of two levers posted at either side of the loom in front of the cloth-beam. These may be fixed into the weaver's bench as shown in the annexed sketch. The pickers are connected to the upper ends of the levers by means of cords that pass round two pulleys fixed in the upper batten of the lay. The lower ends of the levers are attached to the lower batten of the lay also by means of cords. The pickers are drawn towards the ends of the lay by two coiled springs.

Figure V shows the right side of the loom at the shedding and picking motions and Figure VI shows it at the beating motion. As the lay is sent forward, as shown in Fig. V, the lower ends of the levers are also drawn forward along with it, bringing backward the upper ends of the levers which pull up the pickers thus throwing the shuttle into the shed. Here the shuttle is projected from the right box. As the shuttle passes out of the shed the lay is drawn back for the beating-up motion as shown in Fig. VI. With the lay the lower ends of the levers come back whereby the upper ends of the levers go forward and allow the pickers to be

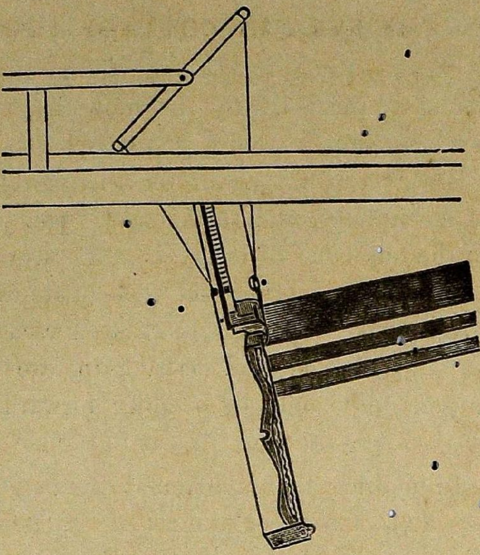


Figure V.—The Sayajee Cottage Attachment *at the shedding and picking motions.*

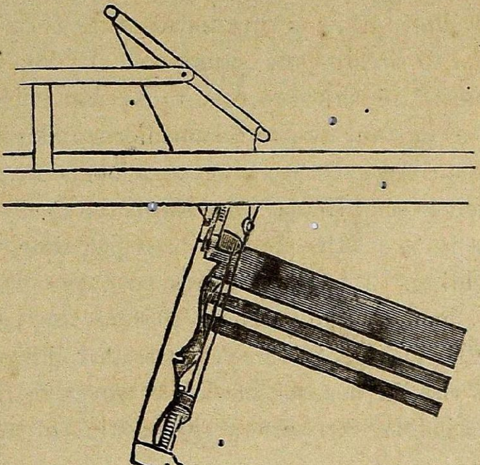


Figure VI.—The Sayajee Cottage Attachment *at the beating motion.*

drawn towards the ends of the boxes by the springs. This makes room for the shuttle in the box to which it is thrown. By the movement just described, the shuttle would go to the left box. The lay is sent forward again for the shedding and picking motions, and the shuttle is now projected from the left box. The lay is again drawn back for the beating motion and the shuttle returns to the right box. The shedding is effected by the feet. The picking and beating-up are effected with one hand only by sending forward with a slight jerk and drawing back with a glide the lay.

In making this attachment, the length of the levers and of the cords must be such that the pickers throw off the shuttle as the lay reaches the limit of its swing forward and the pickers recoil to receive the shuttle as the lay is drawn back. The shuttle-boxes must be longer than those in the fly-shuttle loom to make room for the springs. In working this loom, care must be taken to send the lay forward as the shed is opened, that is, to get the picking in proper time with the shedding. In all other respects, the working of this loom is the same as that of the Indian fly-shuttle loom. At the Industrial Exhibition held last year in Benares, cloth was woven in this loom by a lad on 60s yarn. The position of and action

on the warp in this loom being the same as in the fly-shuttle loom, yarn that may be used in the latter can also be used in this loom. The tension on the warp is not affected by a combination of the picking and beating-up motions. The speed of the loom varies between 60 and 80 picks per minute. By this attachment, therefore, the speed is increased, as in place of two movements one only is made, and consequently the loom also needs less skill. But the labour remains the same, for whatever labour is lessened by doing away with the jerking of the handle is added to the swing of the lay by the picking motion and by the increased speed of the loom. Thus it will be observed that in the change from the manual to the mechanical process of weaving, the speed increases, the skill required diminishes but the power necessary for driving remains about the same.

The liberation of one hand by this loom would be an advance upon the present system of hand-weaving in India. It would render this hand possible to be utilised for the taking-up motion, to effect which the working of the Indian loom has at present to be stopped every few minutes, or for some other operation such as changing about shuttles if checks were required to be woven. This attachment should further prove

a great boon to the Indian weaver owing to the possibility of its application to existing looms and to the extreme simplicity of its construction, not to speak of its low cost.

THE SIMPLEX AUTOMATIC LOOM.

This loom is a decided improvement on the fly-shuttle appliance. In it the shedding and picking motions are effected by a continuous action of the treadles. We always held that a combination of these two motions would be more suitable than any other combination of two motions in weaving, picking being really an adjunct of shedding,* and the working of this machine appears to be the most successful of all looms combining two motions that have recently been constructed in the country.

Description.

The structure of the loom is somewhat similar to that of the Japanese machine. See Figure VII. At the bottom of a rectangular frame is hinged the slay A which rocks backwards and forwards on it; *aa′* are the swords of the slay and *bb′* the shuttle-

* "Hand-Loom Weaving for India" by Ghosh & Mukerjee, p. 28.

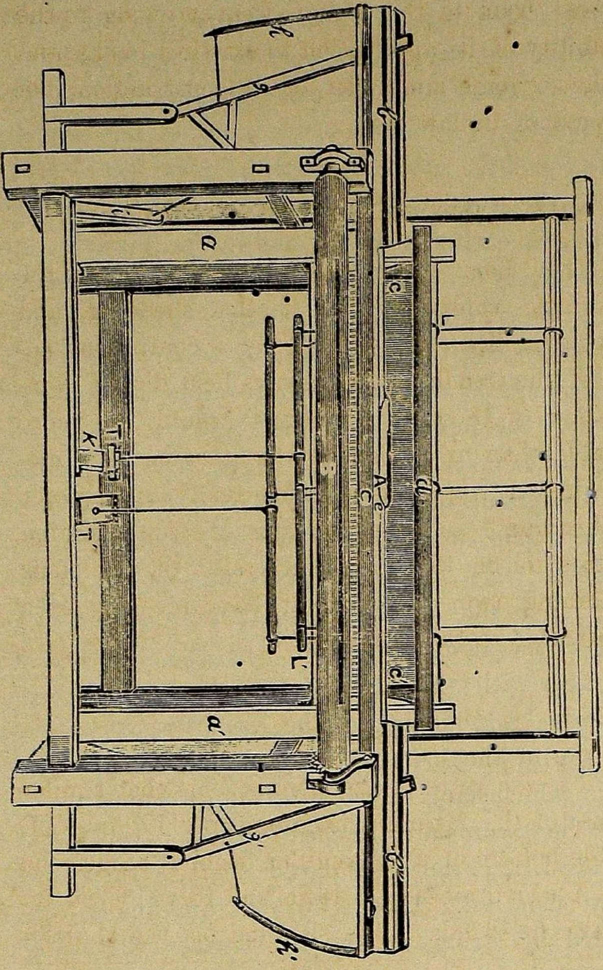


Figure VII.—The Simplex Automatic Loom.

boxes. The top of the slay carries the reed *cc′* which is fitted between its upper and lower battens *d* and *e* otherwise called the slay-cap and the slay-block. On the bottom beam of the slay at either end is fitted a vertical pivot on which work the two picking arms *gg′*. Through the middle of each shuttle-box and in the direction of its length is cut a slot along which plays the picking arm and throws out the shuttle. The arms are pulled towards the ends of the boxes by two bamboo springs *hh′* and are drawn towards the opposite sides by the depression of two picking feet. The left foot is marked *i* but the right foot is hidden by the frame of the loom. The feet are fixed on to two, long, narrow brackets with pedals at the opposite ends. These brackets are hinged on to the inner side of the loom frame and swing up and down along the side. The left bracket is marked with the letter K, but the right one is depressed and hidden by the loom frame. Along the top of the loom is fitted an octagonal roller from which hang three cords being wrapped round it. These cords are attached to the two shafts of healds LL′. From each heald shaft is suspended a wooden rod. These two rods are finally connected by strings to the two treadles TT′ which have their fulcrum at the back of the loom.

The treadles work the healds up and down, and the treading of the treadle on the pedal depresses the picking arm which throws out the shuttle. Thus the *shedding* and *picking* motions of the loom are effected by the feet. The *beating* motion is effected with one hand. At the front of the loom is the cloth-beam B. At one end of the cloth-beam is a thin toothed wheel against which is fixed a click which prevents the beam from unwinding. The winding of the cloth has to be done by hand. The warp-beam at the back is weighted. The breast-beam of the loom is marked C.

Working.

The warp being loomed as described in a later chapter and the shuttle with the weft thread in it being placed in the right shuttle-box, the weaver works the treadles with his feet, that is, presses the right treadle and raises the left one. A shed in the warp is thereby formed. The pressing of the right treadle on the right pedal depresses the right picking foot which quickly draws the right picking arm towards the loom and throws out the shuttle. When the shuttle reaches the left box, the weaver beats up the weft with one hand. With his left foot he then presses the

left treadle which by the connected motions just described throws back the shuttle into the right box. He continues these movements winding up the cloth every now and again with the other hand. All these operations constitute weaving in this loom.

The speed of the loom varies between 80 and 100 picks per minute and yarns up to 120s counts have been woven in it. A practised weaver has turned out really good cloth on this loom.

THE JAPANESE LOOM.

This is a hand-loom of the modern type built for plain weaving. When it was first imported into this country and used in the Punjab its working did not appear to be very successful. For some reason or other the loom was said to cause great breakage in warp threads. A defect of this nature could however be remedied as the strain on the warp, which is generally regarded as the source of this trouble, can always be regulated by various contrivances. It then occurred to certain weavers that to condemn a machine on such slender grounds, which in other respects proved satisfactory, was really unwise. The loom was therefore properly experimented upon and it

was found that the dryness of the atmosphere and defective sizing of the warp had more to do with the breakage of threads than the tension on the warp. We know in one of these looms the use of defective heald-mails was ultimately discovered to be the source of this mischief. The working of the loom was then understood and it began to be gradually appreciated. In the Punjab there is now a firm manufacturing these looms, one of which it worked without any difficulty at the Benares Exhibition last year. The original loom has been worked with success on 40s yarn in Calcutta by Messrs. Khetter Mohun Dey and Co. and Messrs. Jessop and Co. of this city have recently constructed and supplied these machines to certain places in Bengal where they are said to be working satisfactorily. So far as the mechanism of the loom is concerned, it is hardly possible to conceive a machine more simple and yet so complete.

Description.

The framework of the machine is rectangular if the top portion be neglected. See Figure VIII. Within this frame and attached to bearings on the sides are the working parts of the loom. The top or *crank shaft* A extends across the centre of

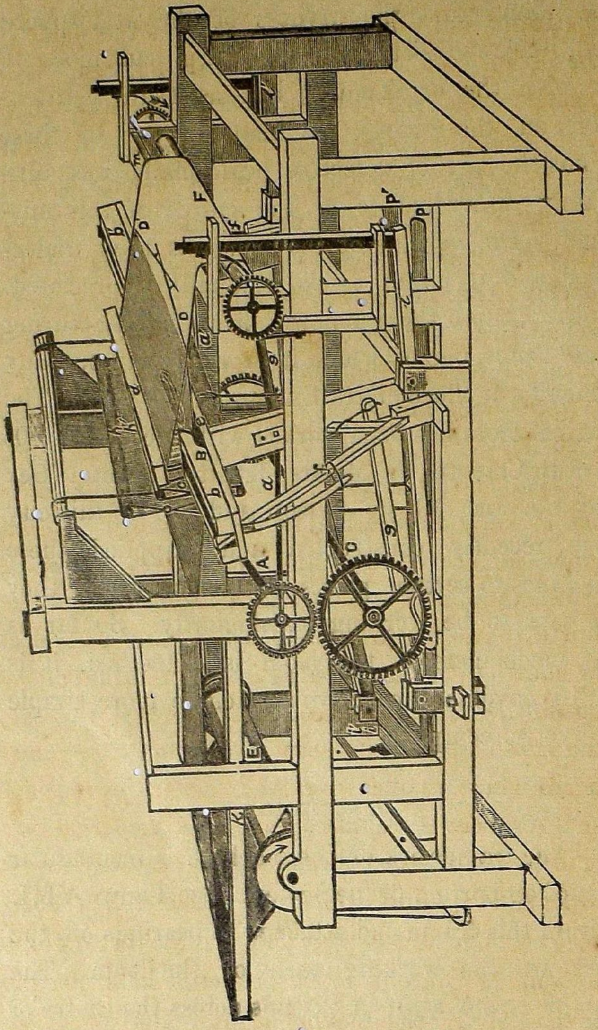


Figure VIII.—The Japanese Loom.

the frame and projects about 3″ on either side of the loom. On the projection at one end is a balance wheel and at the other a small spur wheel. Just inside the frame at each end the crank shaft is bent in the form of an U and by means of connecting rods *aa′* from these bends, the shaft is attached to the slay B. The depth of the bends depend upon the extent to which the slay must rock. Thus the revolution of the crank shaft rocks the slay. The slay rocks backwards and forwards upon hinges on which the frame or board of the slay is mounted. The slay carries the reed *c* which fits into a groove in the slay-block *e* and is kept in position by the slay-cap *d*. The upper surface of the slay-block forms what is termed the *shuttle-race* or the space over which the shuttle passes from side to side. At each end of the shuttle-race is fixed a box for the reception of the shuttle. These are called the *shuttle-boxes bb′*. The sides of these boxes are formed of two wooden boards which have grooves along their inner sides for the guidance of the pickers. The *pickers* are small pieces of wood sliding in these grooves which throw out the shuttle from the boxes. The slay-block which forms the bottom of these boxes has slots cut into it in the direction of its length for the play of the picking arms. The two *pick-*

ing-arms ff′ on either side cause the pickers to throw out the shuttle. On the bottom beam of the slay-board at each side are carried the picking arms, the lower ends of which work on pivots attached to the beam. The upper ends of the picking arms pass through the slots at each side of the slay-block as described above. Below the crank-shaft and similarly working on bearings is the bottom or *tappet shaft* C which actuates the shedding and picking motions of the loom. It has at one end a large spur wheel which gears into the small spur wheel which drives the crank shaft. The spur wheel of the crank shaft usually contains 37 to 40 teeth and the spur wheel of the tappet shaft twice the number, so that *the crank shaft makes two revolutions to one of the tappet shaft*. Attached to the tappet-shaft are two cams which actuate two levers extending from the framework of the loom. The cams are fitted into the shaft at points other than their centres and their projections from the shaft depend on the extent to which the shed must be opened. These levers *ii′* are connected by strings to the two shafts of healds *hh′* which are themselves connected to each other by cords which pass over an octagonal roller at the top of the machine, so that if one heald-shaft is lowered the other

rises and *vice versa*. The revolution of the tappet shaft elevates and depresses the two levers and these motions are conveyed to the two heald-shafts. Thus the alternate rise and fall of the two heald-shafts produce the *shedding motion*. In small machines there are only two levers in the centre, and in large machines two pairs of levers, one pair at either side of the loom. One series of warp threads pass through one shaft of healds and the other series of warp threads pass through the other shaft of healds. The two series form the alternate threads of the warp.

At each end of the tappet-shaft and just inside the loom frame are the *picking tappets* or wipers. These tappets are fixed on the bottom shaft with their points set exactly opposite to each other. The length of the tappets depend upon the strength required for the picking motion. As the bottom shaft revolves, it carries these tappets around which in each revolution gently tap or strike their respective *picking rods gg'* which work on pivots in brackets attached to the loom frame. The ends of the picking rods are tied to the picking arms by means of strings or leather bands. The treading of the tappet upon the picking rod causes it to be depressed and thus the picking arm being attached to it conveys a sharp

blow to the picker working in the grooves of the shuttle-box. This sudden stroke of the picker drives the shuttle through the shed to the opposite box whence it is returned by the corresponding action on the other side. This reciprocal action constitutes the *picking motion* of the loom. The shedding and picking motions of this loom are seen in Fig. VIII.

Immediately after the insertion of a pick, the slay swings forward with the weft thread and beats it up to the woven cloth DD′. The rocking of the slay is uniform, so that it beats up the weft at the same point every time. This is the *beating-up motion* in the loom which is actuated by the crank-shaft as shown above.

In front of the loom is the cloth-beam F at the ends of which are fixed two small spur wheels which abut against the clicks of two ratchets. These ratchets rest on two levers *ll′* which are depressed at regular intervals by the revolution of the tappet-shaft. On the side opposite to the ratchets are two rack-bars the clicks of which also abut against the spur wheels. The depression on the lever raises the ratchet which then sinks being weighted at the top and turns the wheel one tooth at a time, thus rolling up the cloth as it is woven. The rack-bar holds the wheel back and

prevents the beam from unwinding. This forms the *taking-up motion* of the loom and is based on the principle adopted in power-looms. From this system it will be apparent that in looms with automatic taking-up and beating-up motions, the closer the weft threads are required the slower should be the speed of the take-up wheel, and the wider are wanted the threads the faster should be this speed. The speed of the wheel can be regulated either by the play imparted to the lever, so as to increase or diminish the number of teeth turned in one movement, or by a change of the wheel itself into another with a greater or less number of teeth. The former system of regulation is adopted in Hattersley's hand-loom but both the systems are utilised in power-looms. It will be further evident from a study of this excellent warp-pacing arrangement that in looms having no automatic take-up and beating motions, the weft threads cannot be evenly regulated but are usually placed against one another. In such looms, therefore, cloths with bare weaving such as mulls and muslins if woven would not have an uniformly regulated texture. It may here be noted that to determine the number of picks per inch of cloth, both the take-up and picking motions must be automatic.

At the back of the loom is the yarn or warp-beam E. The beam is kept stiff by weights attached to ropes which are wound round the flanges at either end of it. The breast-beam is marked *m* and the back-rail runs from *k* to the opposite side of the loom. PP′ are the treadles having their fulcrum at the back of the loom. Attached to the treadles are two cranks fitted into bends in the bottom or tappet shaft.

Working.

Having prepared and loomed the yarn as further on described in the book, the weaver works the treadles and the following movements take place. The tappet shaft revolves and with it the crank shaft. The slay is sent backwards, the warp is opened or shedded, the shuttle is propelled from one end of the slay to the other through the 'open shed' leaving a thread of weft in its track and the slay swings forward placing the weft thread a few inches off the cloth-beam. The warp then closes upon and secures it there. At the point when all warp threads are on a level there is a 'closed shed.' This completes one pick in the web and the movements are then immediately recommenced. The slay swings back and the shed opens in the opposite direction. The

warp threads that were raised before are now lowered and those that were lowered before are now raised. The shuttle is thrown back to the box whence it was projected again leaving a trail of weft behind. The slay again comes forward and beats up the weft to the fell of the cloth, thus finishing the insertion of the second pick. The repetition of these movements constitute weaving in this loom. The taking-up motion as described before is automatic.

The weaver, therefore, of the Japanese Loom does not use his hands but merely works his feet and all the motions take place. As he uses little skill, he should really be called the operator of the machine. The speed of this loom is ~~about twice~~ as much as that of the Indian fly-shuttle loom and cloths up to 40s counts are best woven in it.

The modern hand-loom, an idea of which may be obtained from the make of the Japanese Loom, is a simplified form of the power-loom. Its construction may be regarded as the foundation upon which the power-loom of the common type could be built and over which special harness being added the power-loom of the fancy type might be reared. The main points of difference between the hand-loom and the power-loom of the present day may however be noted. In the hand-

loom the bottom shaft is connected to treadles which are worked by foot, in the power-loom the top shaft is connected to a driving pulley which is worked by steam. In the former there is no 'weft-fork' nor 'friction-driven cloth-roller' there being no need for them. The 'weft-fork' has already been spoken of and the 'friction-roller' will be explained in the chapter on the improvement of looms. In the latter there are besides certain minor parts which are not found nor required in the hand-loom, such as the roller-temple and the Burnley brake. It will therefore be evident that the power-loom differs from the hand-loom in those points only which enable it to work at a higher speed, to use a longer warp and to handle a larger quantity of cloth. The modern English hand-loom by reason of its high price and complicated parts is not quite suited to the Indian weaver. But it is a loom in which attachments for fancy weaving and coloured mixtures may be obtained. Those of our readers who are able to purchase and use them may be recommended to Messrs. Raffael Bros. of Manchester, Geo. Hattersley and Sons, Ld. of Keighley and Robert Hall and Sons, Ld. of Bury.

CHAPTER IV.

Efficient Weaving.

Efficient weaving consists in turning out good cloth, that is, cloth with a firm, even web and with neat edges. In this regard, the tension on the warp is a matter of primary importance. This must not be too much nor too little. In the former case, great strain would be necessary in working the healds to open the shed and warp threads would thereby give way. In the latter case, the web would spring at the beating motion and the weft thread go either above or below the fell of the cloth.

To obtain a firm and even web, breakage in the weft and warp threads, bareness and cracks in the cloth must be avoided. Breakage in the weft thread can be prevented by getting the shuttle to act properly as shown later on. The snapping of warp threads may be due to there being an unusual tension on the warp which is relieved by lessening the weights below the warp-beam, or to dryness in the atmosphere in which case the threads are damped occasionally. As an alternative measure, weavers sometimes dig a hole

under the warp which retains cool air and keeps the threads moist. It may here be observed that a humid atmosphere naturally favours the weaving operation. The success of Lancashire in the weaving industry has been attributed to a certain extent to her damp climate; and in this respect, Bengal, Assam and Western India are particularly suited for the industry. As a precaution against smashes in the warp the width of the reed must be sufficient to allow the formation of a proper shed, that is, the shed must not be bent in by the upper or lower batten in the Indian loom, and in the Japanese loom by the slay-cap or slay-block. The English and Japanese reeds being wider are better for this purpose than the Indian reed; they lessen the possibility of the shuttle grazing the upper portion of the shed and snapping the warp threads. The width of a reed should be about 3″ so that about 2″ may be available for the shed.

Bareness and cracks in the cloth may be caused by the warp not coming off the beam uniformly, which may be due to the necks of the warp-beam being rusty or to the weight-ropes being damp, in which latter case they should be replaced by dry ones; or they may be caused by the cloth not being taken up evenly, which may be due to the

wheels of the cloth-beam not being deep enough in gear, in which case they slip back. Bareness and cracks in the cloth may also be caused by the tappets treading the rods too late and thus delaying the pick or by the weft thread breaking during the pick.

To have neat edges the temples must hold out the cloth to its proper width and with an equal tension on both sides. The picking also must not be abrupt for then the selvages would rebound by sudden contact with the warp and would not be firmly placed.

As efficient weaving implies the production of good cloth, it is obvious that this cannot be done unless the loom is properly adjusted and worked. This would necessitate attention to the following details. In passing it may be noticed that the adjusting and equipping of a loom in cotton mills is a special item of work and is known as 'gating.'

Correct formation of the shed. The healds should be elevated and depressed within a fixed space so as to form a shed the upper portion of which will permit of a clear passage for the shuttle and the lower portion rest on the slope of the shuttle-race in a perfect line with it. If the shed is bigger there is an unnecessary strain on the warp, if smaller the shuttle gets caught in it.

Having determined this space, its measure should be adhered to by working the treadles of the Indian loom within that limit. In this loom there is no mechanical device for obtaining an uniform shed which is really a defect in the machine. Its treadles should therefore work within a *guide-frame* made in this form .

Proper action of the shuttle. If the shuttle jumps out or turns over, either the shuttle-race is not on a level or the shuttle is not flat at the bottom or the reed is crooked or the pick is too strong. To prevent these irregularities, the shuttle-race must be perfectly level, the bottom of the shuttle quite flat, the reed absolutely straight and the strength of the pick easy. If the shuttle rattles in the box, the picker may strike the shuttle too high. See that it strikes the shuttle just at the tip. Any of the above defects may also be caused by the loom picking too soon or too late. This is one of the most important items in the working of the Indian loom and in the fixing of the Japanese loom. *A loom should always pick in proper time for the shedding motion.* In the Indian loom, the action of the hand in picking must quickly follow up the movement of the feet in shedding. In the Japanese loom, the tappets must be set exactly opposite to each other in such

a manner that when the bends of the crank shaft are at their bottom centre, the treading of the tappets should commence. The picking will then follow up the shedding.

Uniform swing of the lay. The swing of the lay in the Indian loom must be limited within a certain range as in the power-loom. This space must be the distance between the fell of the cloth and the front heald-shaft. If it swings back beyond this limit, as it sometimes does in this loom, there is an unnecessary strain on the warp at the upper and lower battens. This is another defect in this loom which should be remedied by fixing a stop-rod at either side of the loom in a line with the healds. These rods have been recently adopted in a loom which is working satisfactorily at a weaving school in Calcutta. It must also be remembered that the swing of the lay is greater for coarse yarn and smaller for fine yarn, as in the latter a heavy beat would injure the warp. For this reason, the finer counts of yarn are sometimes woven in a small loom in Bengal which may be seen at Santipur, Atpur and Joynagore. An adjustable lay is therefore necessary where cloths of very different counts are woven in the same loom. The cross-rails in the Indian loom should be provided with grooves along which the lay may

be adjusted as shown in Figures III and IV. The lay must be so adjusted as to depend from a point midway between the fell of the cloth and the front heald-shaft.

Having studied the proper adjustment of the loom and the theory by which efficient weaving may be ensured, it remains for the student to learn the operation of weaving practically on the loom. This operation has been explained in the previous chapter after the description of each machine, but the details of the process constitute certain simple items of work which will naturally suggest themselves to the weaver in the practice of the art.

CHAPTER V.

THE PREPARATION OF YARN.

The preparation of yarn is an important section of the weaving industry. It requires every care and attention on the part of the weaver. Unless the yarn put on the loom has been properly conditioned, weaving is troublesome and slow and the fabric produced of a poor quality. To ensure therefore good weaving yarn must be well prepared. When yarn comes from the spinning mill, it is composed of more or less loose fibres and has in consequence little strength. It has therefore to be treated in the undernoted manner to be fit for the hand-loom.

Sizing. The yarn is squeezed or slashed in a liquid composed of starch and other ingredients called 'size.' This is done to consolidate the fibres and thereby impart strength to the yarn. Sizing also includes dressing which consists in laying down the fibres so as to glaze the surface of the yarn. Apart from its value in the cloth, this process renders the yarn fit to stand the strain and friction on the loom. It must be observed that yarn for the warp is invariably sized, but yarn for

the weft is usually not sized, as much unlike the former, it is subjected to very little strain and friction during the process of weaving.

Drying. The sized yarn is then dried, after which all the yarn for the warp and weft are put round swifts.

Winding. The warp yarn is then wound on bobbins but sometimes they remain on the swifts. *The Bobbin is a small wooden cylinder flanged at both ends.* The yarn required for the weft is wound on pirns. The yarn is thus put up in a convenient form. Warp yarn is often referred to as 'twist' but with no special significance as all yarn is twisted in the process of manufacture.

Warping. The yarn from the bobbins or swifts is then divided into the number and length of warp threads required for the cloth to be woven. The warp is next wound on sticks or sometimes on a large reel. It must here be remarked that yarn for the weft is not divided into the number and length of threads like yarn for the warp, as the weft of a cloth consists of a continuous thread which is returned at the edges. The total quantity of weft required for the cloth is merely wound on pirns as stated above in lengths as each will hold after which the preparation of weft yarn is completed.

The Indian method of preparing yarn for the hand-loom is as follows :—

Wetting. The yarn is steeped in fresh water for a day or two. This is done to strengthen it.

Sizing. The yarn required to be sized is then taken hank by hank and squeezed in a fluid till the threads are thoroughly permeated with it. In Bengal the fluid is made usually of roasted paddy (*khoi*) and tamarind, and in Madras of rice flour and gingelly, boiled in water. The wet hank is next taken and placed round a swift (*charki*). From the swift the thread of the hank is passed between two grains of wet *khoi* or a gelatine made of the last named fluid pressed between two fingers and then wound on small reels (*natai*). This is called single sizing and is a very perfect process, as it sizes every side of the yarn and thoroughly smoothens it. The essence of single or hand sizing is the treatment of threads individually between the fingers of a hand which act intelligently enough to press it just sufficient to glaze its surface yet not so much as to stretch or break it. Any system, therefore, that does not possess this particular virtue cannot be as perfect.

Drying. All the hanks being thus treated are then dried on reels in an open place. The hanks are then taken out of the reels from their tapering

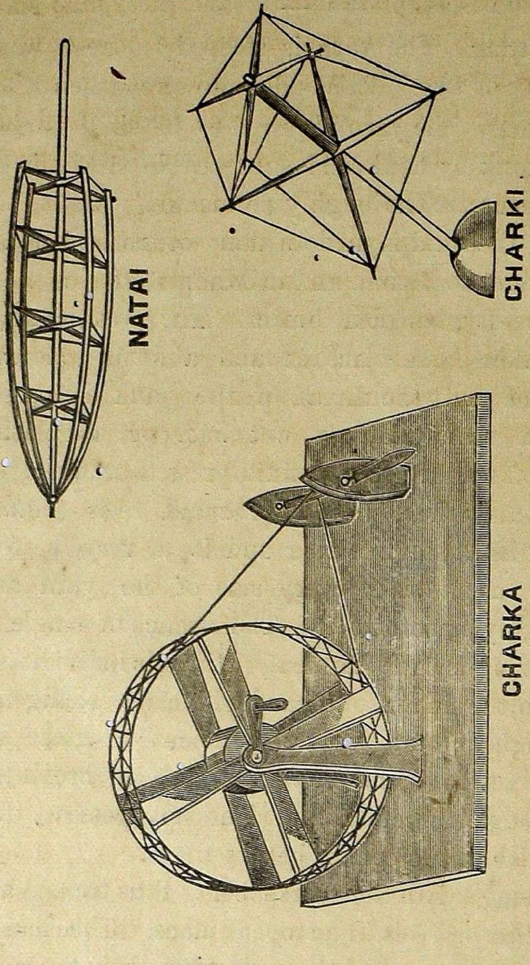


Figure IX.—The Indian weaver's implements.

ends, which are thus constructed to facilitate this quick mode of transference, and put round small swifts. They are so transferred as it would be very inconvenient to unwind the yarn from the reels owing to their central rods being fixed into them. The unsized yarn is also mounted on swifts.

Winding. The weft yarn is next wound on pirns. The warp yarn is then wound on bobbins when it has to be warped according to the modern system of peg warping, but if it has to be warped on sticks in the ground or according to the old system of peg warping, the warp yarn remains on the swifts where they were transferred as stated above. The winding on the bobbins and pirns is done in the spinning wheel (*charka*). The bobbin or pirn is fixed into the spindle of the spinning wheel. The swift with the hank of yarn round it is placed on a round lump of earth beside the spinning wheel and the end of the yarn is fastened to the bobbin or pirn. The spindle being connected to the wheel by an endless cord revolves as the handle is turned and so winds the yarn on the bobbin or pirn fixed into it. The weaver turns the wheel with one hand and guides the thread along the bobbin or pirn with the other. Here ends the preparation of weft yarn. Where the modern system of peg warping is adopted, the bobbins

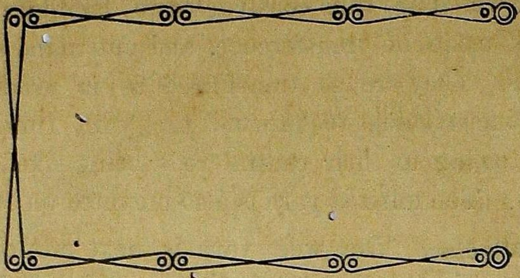


Figure X.—The Indian method of stick warping.

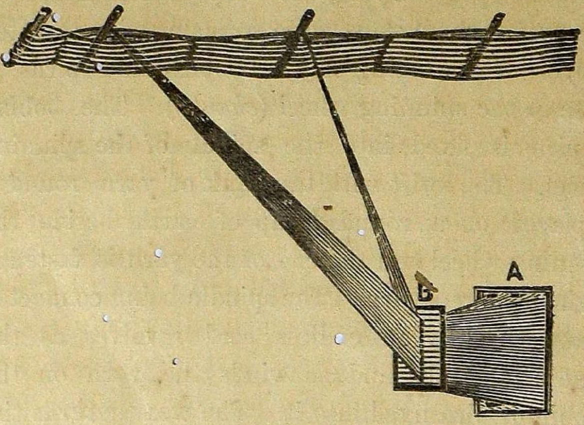


Figure XI.—The modern system of peg-warping.

are then put in a bobbin-frame. Illustrations of the *charki*, *natai* and *charka* are given in Figure IX. The two former implements are made of bamboo and the latter of *sundri* or *sal* wood.

Warping. The warp yarn is then divided into the number and length of warp threads required for the cloth in either of the two following ways known to Indian weavers as the *tanah* process:—

(*a*) Sticks about 3 ft. long are fixed into the ground in couples and usually in two rows as shown in Figure X. The sticks at the ends of the rows are stronger than the intermediary ones to bear the strain of the warp. They are about 3in. apart in each couple and the distance between two couples is about 4ft. The warper holds the swift in his hand, fastens the end of the thread to an end stick and takes the thread along from stick to stick placing it outside one and inside another in succession as shown in the figure. When he comes to the last stick he passes the thread around it and retraces his steps to the first stick repeating the process. Thus he goes to and fro from the first to the last stick laying out his yarn. The distance occupied by the sticks on the three sides of the figure forms the length of the warp and the rows of thread along the sticks from top to bottom form the number of warp ends. The use of the

intermediary sticks are to form leases and so prevent the threads from getting entangled. These warp threads are then collectively wound on an end stick together with the other sticks. The sticks are, ofcourse, pulled out of the ground.

(*b*) Instead of sticks in the ground, pegs are driven into a wall, about 4 ft. apart, all in a line. In former times, the yarn was then warped in the pegs, precisely in the manner done for the sticks in the ground. In later years, it struck the warper that the labour of treading over a space equivalent to the length of all the threads of the warp combined together may be obviated by carrying more than one thread at a time. A new method was then adopted in peg warping with the help of a lease-taker called the *bahr* in the vernacular. A *bahr* is a small wooden rectangular frame containing ribs made of bamboo strips which have holes in their middle.

By the modern method as shown in Figure XI the ends of the threads are drawn out collectively from say 40 bobbins placed in a bobbin-frame A and passed alternately through the eyes and between the ribs of the lease-taker B. The alternate series of threads are then separated, thus forming a lease. The two alternate halves are next taken in two bunches, knotted together and slipped

through the first peg so that one bunch of threads go over and the other go under the peg. Two men generally work at this process—the warper and the carrier. The former takes leases and does the warping, the latter carries the bobbin-frame. The bobbin-frame is placed beyond the second peg so that one extremity of the threads are in the frame and the other at the first peg. The frame is then carried beyond the third peg when the bunch that was under the first peg is put over the second and the one over the first is put under the second. The alternate bunches are then similarly taken over and under the succeeding pegs, knotted together and slipped through the last peg. This first section of warp is then shoved right into the pegs, nearest to the wall. Similarly as many sections as would make up the required number of ends for the width of the cloth are then, one after another, warped and fixed into the pegs. If 1200 ends are required 30 sections are taken. The distance between the first and the last peg forms the length of the warp required. Finally all the sections from the first peg are taken out one by one and slipped through a rod held in the hand which thereby protects the leases and the warp is rolled on it. The leases of the succeeding pegs are transferred to other lease rods which are then

rolled up with the warp as in the case of the sticks from the ground.

All the above operations in the Indian system of yarn preparation should be performed in the foregoing order, although every weaver does not do so. Particularly, sizing should be done previous to warping, for unless the threads are strengthened by the size they would break or get thin by the stretching in the warping process. It may here be noted that the most essential point in the preparation of yarn is the retention of the elasticity of the thread so that it may be available for the strain in the loom. This is insisted upon by several writers on weaving notably Marsden who says—"In fact, in all the processes of manufacture preceding the weaving, it should be regarded as a cardinal principle that the yarn should never be stretched or in any way have its elastic strength drawn upon, as this is strained to the utmost in weaving."* In the English system of yarn preparation sizing is never done before warping as to make the process of sizing expeditious many strands of yarn are sized together, and if many threads are to be arranged together as a preparatory process for sizing, they might as well be warped. But it is this warping of unsized yarn

* Marsden's "Cotton Weaving," p. 281.

that destroys a portion of its strength. This is another reason why the Indian method of single sizing produces a stronger warp than any English system of sizing. This perfect process of hand sizing and of weaving on a diminutive loom rendered it possible for weavers in Bengal to weave Dacca muslins known as 'running water' and 'dew drops' from yarn equivalent to 524s counts which far exceeds the finest yarn spun at the present day. It was possible to spin such fine yarn owing to the special quality of cotton used in its manufacture and to the particular care bestowed on the spinning.

It will nevertheless be seen that the Indian system of yarn preparation though excellent in its sizing process is extremely tedious, needs much labour and yet produces a short warp. This has always been a drawback with the Indian weaver. The English system of preparing yarn is far less laborious and very much quicker. But the difficulty that the Indian weaver has to contend with is not so much the delay or worry in the sizing process—which is simple and rapid enough for the domestic weaver's requirements—as the great time and trouble required for the warping process. What therefore calls for immediate reform is in this direction. A small warping machine similar

in principle to the English machine is of the utmost necessity to him. Such a machine will be described hereafter. We shall now proceed to see the principles upon which yarn is prepared in England, the systems followed in other countries being based on them. Having done so, we shall be able to decide how far these principles would be useful or applicable to our industry.

Winding.

In the power-loom industry, this process is elaborate owing to the various forms in which yarn comes from the spinning to the weaving division and also owing to the different requirements of the yarn after winding. Thus in the power industry yarn comes either in hanks, mule cops or ring-frame bobbins, and is wound either for grey, bleached or dyed goods. For grey goods, yarn is usually taken from its original form into the warper's bobbin or the weaver's pirn, but for bleached and dyed goods it is first wound on reels and subsequently rewound on bobbins and pirns. Then, besides the general style of single yarn winding, double or multiple yarn winding occurs in special branches of the industry. Winding in weaving mills is, therefore, not only intricate but

repeated and the machines used for it are necessarily of various construction.

In the hand-loom industry, winding is simple but somewhat similar to the system adopted in mills. The yarn is usually purchased in hanks and is wound from them direct into bobbins for the warping process and into pirns for the weaver. The machines employed in this section of the industry may here be described.

Bobbin-Winding. The bobbin-winder consists of two parallel shafts resting on supports. At the middle of one shaft is fitted a pulley and at the ends are fixed the bobbins. The pulley is connected by a cord to the driving wheel. Thus the revolution of the driving wheel revolves the bobbins which thereby wind the threads round them. The other shaft which forms the regulator or guide-rod touches a cam also connected with the driving wheel. The regulator guides the threads and thereby distributes them evenly along the bobbins.

Pirn-Winding. There are two types of pirn-winders—the disc pirn-winder and the cup pirn-winder. The disc pirn-winder consists of a set of discs with bevelled edges which touch the pirns mounted on spindles. The discs are fitted into a shaft which is made to revolve by a driving wheel

at one end. The revolving discs being in contact with the pirns wind the threads round them. The cup pirn-winder consists of a number of spindles on which are fixed the pirns. The spindles are placed in cups and the lower ends of the spindles fit into holes in horizontal cog-wheels which are connected to each other. These wheels are made to revolve by a driving wheel at one end. The guiding is done by a regulator.

As grey goods only are manufactured in this country, no reeling is required and these winders would suffice for the hand-loom industry. They are however not essential with one or two looms, the *charka* being sufficient in such cases, but would be indispensable in factories having several looms.

Warping.

Ball-Warping. In England a system of peg-warping almost identical to the Indian process prevailed up to the latter half of the 18th century. Ball-warping was then introduced. The appliances for this new process consisted of a large vertical reel with a coarse comb attached to its side and a driving pulley connected to it by an endless cord. A bobbin-frame otherwise called a creel with about forty bobbins of yarn completed the plant.

The warper took the ends of yarn collectively from the bobbins, passed them between the teeth of the comb and tied them together to a peg in the reel. The threads were next taken under and over lease pegs as in peg-warping. The reel was then revolved. The length of the warp was calculated by the number of its revolutions, and the number of threads by the ends of yarn taken at a time. The warper then severed the threads from the creel and wrapped the warp round his arm making it into a ball. This style of doffing the warp gave the name to the process. It was an improvement on the laborious method of peg-warping and so came into vogue.

Section-Warping. About the year 1875, a process more convenient than ball-warping, particularly for the coloured goods trade, was introduced in England. To obtain small warps for different colours, it was necessary to prepare the warp in sections of yarn, each section representing a colour and all the sections making up the width of the cloth. This process was therefore called section-warping and it prevails up to the present day. The section-warping mill consists of a large creel usually semicircular in shape containing about 250 bobbins, a wide reed, a contracting reed, a diminutive beam called the section-block, besides

attachments for winding, compressing, marking and doffing. From these bobbins, as many strands as will form the section of yarn are taken and passed through the wide reed. They are next taken through the contracting reed which reduces their width to that of the section-block on which they are then wound. This process is continued till as many sections as are required for the width of the cloth are warped.

Beam-Warping. This system has come into existence in recent years in the power-loom industry only. To meet the requirements of large weaving establishments section-warping was found inadequate and in the old system of ball-warping there were certain defects such as the twisting and entangling of yarn. But by this method warp is prepared in thousands of yards at a time, and the threads do not twist or tangle. The beam-warping machine consists of a creel holding beams instead of bobbins of yarn. Over these are fitted tension rollers which keep the yarn uniformly stretched. At a little distance from this beam creel is the head-stock of the machine consisting of a curved conductor, a ring, a wheel carrying two small bobbins of thread, a marking roller, friction pulleys, a carrier roller and a receiving sack. Between the beam creel and the headstock is a stand with guide

rods. The yarn from the beams go over the tension rollers and guide rods. It then tapers into narrow bands which pass under the curved conductor and enter the ring. Over the ring revolves the wheel with its bobbins. As the newly formed warp passes from the ring to the marking roller, the bobbin thread turns round it once in every 8 or 10 inches and so binds up the warp thus keeping its threads together. At the roller, the warp is marked at every piece-length. It then passes round the friction pulleys, over the carrier roller and finally enters the receiving sack.

Chain-Warping. This is another system adopted for yarn which has to be bleached or dyed. The yarn is warped and linked in the form of a chain, thereby lessening its length considerably. This reduces the labour in the bleaching and dyeing process. The chain-warp is formed either direct from the creel or from the ball, section or beam warp.

From the above systems, it is apparent that though the processes vary according to the requirements of the warp, the principles of warping are the same in every system. The leases are formed, the length of the warp is determined by the number of times it goes round a reel, beam or

roller and its width is calculated by the number of threads drawn from the bobbin-frame or creel.

HAND-WARPING MACHINE.

Perhaps the simplest and most complete warping machine yet constructed for the hand-weaver in England is the warping mill and creel of Messrs. Geo. Hattersley and Sons. A similar machine with a heck or lease-taker and a counting rod to suit the Indian weaver could be constructed in this country at a small cost and should be adopted by him. An illustration of such a machine is given in Figure XII.

Description.

A is the bobbin-frame or creel holding about 60 bobbins of yarn. B is the heck or lease-taker consisting of two small frames having horizontal ribs fitted into them from top to bottom. At the middle of the ribs are perforations which are called the 'eyes of the heck.' The frames hang from and slide along two iron rods. The function of a heck is to form or take leases in the warp as described below. In weaving mills, a reed attached to the warping machine generally performs the function of a heck. The leases are formed by

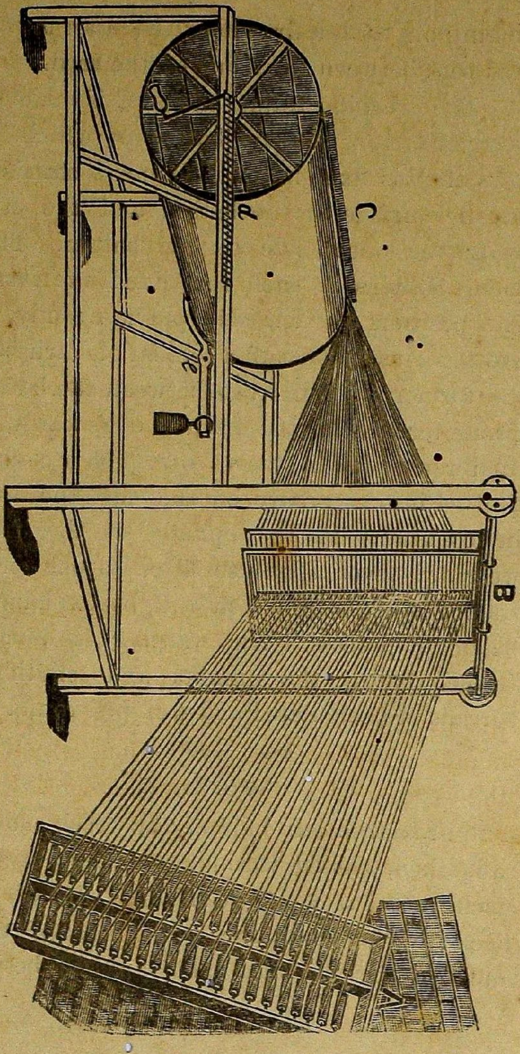


Figure XII.—Hand-Warping Machine.

picking out with a drawhook the alternate threads that pass between the dents of the reed.

The warping frame or reel C is made of light wood and iron, the top batten of which has two rows of pins fixed into it. One row stands upright on the surface of the batten and the other lies along the outer side of the batten. There are about 50 pins in each row fixed *one inch apart.* The position of each side pin is exactly between two top pins, so that if a section of yarn be tied to the former, it will wrap between the latter. The circumference of the frame is $3\frac{1}{3}$ yards, and at each revolution it moves one inch a counting rod *d* fitted into a groove on the side, the rod being in contact with the spindle of the frame. A weighted lever *l* is also fitted to one end of the frame, the use of which will be explained in the beaming process. The warping is done on this frame, that is, the number and length of warp threads are calculated and wrapped round it.

Working.

From the left half of the creel, ends of yarn are taken, passed through the eyes of the front heck-frame and between the ribs of the rear heck-frame. From the right half of the creel, ends of yarn are also taken, passed between the

ribs of the front heck-frame and through the eyes of the rear heck-frame. If 40 threads are calculated per inch of cloth 20 ends from each half of the creel are to be taken. The 40 ends are then collected together and tied to the side pin at one end of the frame. The lease is now formed by sliding the rear heck-frame to one side, till the threads from one half of the creel cross the threads from the other half, thus forming an end lease. The lease is preserved by a loose knot tied round it with coloured thread. The frame is then revolved and the section of thread falls between the 1st and 2nd top pin, that is, the first inch space. If the length calculated for the warp be 110 yds., the revolution of the frame must be 33, or the counting rod travel up 33 inches. After 16 or 17 revolutions, that is, about the middle of the warp, another lease has to be formed and protected as aforesaid. This is called the beer lease. After 33 revolutions another end lease has to be similarly taken and the tail of the section tied to the side pin where the head was also secured.

Threads from another 40 bobbins replaced in the creel must be now leased and wound on the next inch space of the frame and so on till as many inch spaces are filled with sections of warp as the inch width calculated for the cloth; say,

if 46 inch width be calculated, 46 inch spaces are to be filled.

Having recommended as the result of our investigations, the foregoing method of warping to handweavers in this country, we pass on to see the principles upon which the English system of sizing is based.

Sizing.

Hand-Sizing. The most primitive method of sizing in England was that carried on by the hand-weaver who brushed his warp with size on the loom and also dried it there during intervals of weaving taken for these operations. Thus only a small portion of the warp–that which was exposed in the loom–could be sized at a time. This old method was naturally found to be very slow. About the beginning of the last century, a system was inaugurated to size the entire warp at once before putting it on the loom. The hand-weaver put his warp into a trough about 4 or 5 feet long which he then filled with boiling size. The warp was passed through a hole in one end of the trough and under a roller to the opposite extremity, thence over another and back to the end of the trough whence it started. After this, it was passed out through a smaller hole so that the superfluous size

in the warp was squeezed out of it and ran back into the trough. Having saturated the warp well in the size, he drew it out through the trough and dried it on a frame. This mode of sizing had many defects. An attempt was then made to put a coating of size on the entire warp by means of brushes in a machine, just as the handweaver sized small portions of it by hand in the primitive method. William Radcliffe the Stockport inventor was the first to suggest this idea of mechanical sizing to Thomas Johnson a weaver in his employ. Johnson succeeded in inventing the 'dressing machine' which is celebrated as having been one of the instruments by which the power-loom attained commercial success. But the principal difficulty with this process, which was carried on for some years, was that the brushes could not penetrate a dense warp and the sizing of the threads was by no means uniform.

Tape-Sizing. It was then found from this accumulated experience that to size the threads of a warp properly and uniformly the principles that should govern the process must be (1) a thorough immersion of the warp in the sizing fluid instead of the application on it of a mere coating of size, and (2) that a thin layer of warp threads rather than a dense mass of it must be so treated

at a time. These theories were worked out practically by Messrs. Hornby and Kenworthy of Blackburn who patented a machine in which the warp passed through a coarse comb in parallel bands or tapes and was thus immersed through the sizing fluid. This was called the tape machine and the process proved to be a more perfect one than any previous method of sizing.

Slasher-Sizing. The slasher-sizing process introduced by Messrs. Bullough, Walmsley and Whittaker in 1853 is an improvement on the tape system in as much as the warp passing through the size in this process is more evenly distributed than in the other. Instead of the warp travelling in the form of parallel tapes it runs in a broad sheet, thereby getting each thread sized more thoroughly and uniformly than in the tape system. The slasher sizing machine consists of a creel holding from 6 to 8 large beams containing the yarn, a pair of small carrier rollers, a size trough, a large and a small steam-heated cylinder, two conveying rollers, a set of separating rods, a fan and certain minor attachments. The size trough is in two sections and contains an immersion roller, two sizing rollers and two finishing rollers.

The yarn from the beams passes over the carrier rollers and goes into the size trough. It is

conducted through the boiling size by the immersion roller and led between the sizing rollers which press the size thoroughly into it. It then passes between the finishing rollers where any superfluous size that may be in the yarn is taken out of it. The wet yarn then goes round the steam-heated cylinders to be dried. One side of the yarn is dried on the large cylinder and the other side on the small cylinder. From the small cylinder the yarn passes over conveying rollers to the separating rods, where the threads of one beam are separated from the threads of another if stuck together. The yarn is then conducted over a rotating fan blowing cool air, which completes the drying of the size, to a measuring roller where the decorative lengths are marked. In some machines, hot air fans are used in place of steam cylinders. The slasher-sizing process is most generally adopted in the grey goods trade.

Hank-Sizing. This is another process of sizing employed in the coloured goods trade where the dyed yarn is obtained in hanks. The ordinary hank-sizing machine consists of an upright rectangular frame which supports a size trough. Above the trough at one side of the frame is fixed a hook and at the other is fitted another hook attached to a small wheel. When the hanks are

thoroughly saturated in the size, they are taken out one by one, suspended between the two hooks and twisted by turning the wheel till all the superfluous size is wrung out of them.

It will now be readily perceived that the above processes of sizing though more expeditious are not so perfect as the Indian method of single sizing; and if some mechanical process could be devised by which the domestic weaver could carry on single or individual sizing with several threads at the same time, a decided advance would be made in our system of yarn preparation. The writer has suggested certain ideas with this object to a local patentee, but unless they are worked out successfully nothing need be said here on the subject. In handweaving factories, however, a more rapid process of sizing would be needed. In such establishments, a system could be adopted similar to the slasher sizing process, where the following changes towards economy might also be attempted:—(1) the finishing rollers in the size-box may be dispensed with and four dressing beams used instead; (2) the steam heated cylinders might also be replaced by a set of fans, two or more in number, in almost every climate of India.

There are some important points in the process of sizing which must now be mentioned. These

items have to be carefully attended to or the sized yarn will turn out imperfect. The most essential point is that the yarn should not be stretched in any way during the process of sizing but should, from the commencement to the end of it, be conveyed by the different parts of the machine working positively. On no account must any portion of the machine work automatically, that is, by the action of the yarn on it. This would naturally cause a strain on the yarn which it must be the foremost care of the sizer to avoid. We have explained at the commencement of this chapter why it is so necessary to take this precaution.

Another point of importance is that the sizing fluid should be of uniform consistency throughout the same warp, as otherwise the appearance of the cloth might vary in the same piece.

Proper drying of the yarn is also an item in this process which requires attention. The yarn must not remain wet nor be over-dried. In the former case, the threads would either get pasted together or be mildewed. In the latter case, the yarn as well as the size would get baked and the threads become brittle. It may however be stated that this latter defect could only arise where cylinder drying is employed.

Size. The sizing fluid is composed of a starch such as rice, wheat, sago or potato as a base, and of an oil such as gingelly, castor, coconut or paraffin as a softener, boiled together in water to make a liquid. A good mixture for ordinary Indian cloth woven of 40s to 80s yarn is as follows:—

Rice flour 8 srs., sago 2 srs., gingelly oil 2 srs. and water 16 gallons* boiled together till a fluid of the required substance is obtained.

A good combination for lower counts of yarn is as follows:—

Wheat flour 15 srs., sago 5 srs., castor oil 4 srs. and water 30 gallons.

These mixtures would be good enough for ordinary circumstances but would be inadequate in a dry atmosphere which renders the warp brittle and thereby causes great breakage in the threads. Deliquescent salts which absorb moisture should therefore be added to the composition in such climates. Chloride of magnesium is the best known salt of this nature and absorbs moisture so rapidly that if it be exposed to the air, it soon becomes a liquid. It is most generally used in sizing, but where the weaver is unable to afford this salt, common salt would serve the purpose. Soap is

* 1 gallon of pure water weighs 5 seers.

sometimes mixed with size as a lubricant and to prevent the threads from adhering to one another but the weaver must be cautioned against its use in size containing salt, for then the two ingredients would decompose and form an insoluble combination. The addition of salt in size always keeps the yarn soft and reduces breakage in the threads. Its use may with advantage be resorted to in the arid climate of north-western India.

Antiseptics are generally not mixed with size in this country as heavy sizing, which favours the growth of germs and the formation of mildew, is not in vogue among Indian weavers.

Piecing. The weaver has frequently to join up broken threads and it is necessary for him to know how to do this properly. Broken threads must not be tied but pieced. Piecing is done by twisting, first one end with the other and then the ends thus joined with the body of the thread, all the time in one direction. If broken threads are tied, they might not pass between the dents of the reed and if joined in any other manner, they may open out. In spinning mills, the work of piecing is so heavy that a boy or girl called the 'piecer' is employed for this purpose.

Marking. Piece-lengths are marked at the warping process. In the Hand-Warping Machine

the marking could be easily done with the help of the counting rod. One piece-length, say 5 yards, would have to be first measured on the counting rod by revolving the reel with 5 yards of warp. If the rod moved up $1\frac{1}{2}$ inch, this space would have to be subsequently taken as the standard for every piece-length. These lengths are marked with ink on the warp. According to the marks, the headings and cross-borders are also placed.

We have seen in this chapter that to prepare his yarn for the loom the Indian weaver adopts single sizing, winding in the *charka* and warping on sticks in the ground or pegs in a wall. For domestic weavers, the aforesaid methods of sizing and winding will yet serve their purpose, although attempts may be made to increase their outturn. But the methods of warping must be replaced by an improved process such as that of the hand-warping machine. For those however that desire to conduct weaving on a larger scale, bobbin and pirn winders together with the warping machine as well as a process of slasher sizing would have to be resorted to, that is, the English system of yarn preparation with its order of procedure would have to be more or less followed. Owing to the large quantity of yarn required to be treated at once, it would have to be put up in a convenient form to

begin with, that is, winding would be done first. Then, in order to size the yarn in the form of a sheet as in slasher sizing, the threads would have to be previously arranged side by side, that is, warping would be done next. Sizing would therefore be the last operation.

CHAPTER VI.

Looming the Yarn.

The yarn being prepared as described in the preceding chapter is set on the loom in advance of weaving in the undernoted manner.

Beaming. This process consists of transferring the warp from its previous situation in the sticks or the reel to the weaver's beam in such a manner that the threads lie parallel to each other and are distributed evenly along the beam. In this process, the warp is also examined, broken threads pieced and knots in the warp cleared.

The Indian weaver places the loom-beam over trestles in the ground. He then takes the ends of the warp from the sticks, passes them between the dents of a reed and wraps them round the beam. Having thus led and fixed all the ends to the loom-beam, he winds them up collectively on it in the manner above described. During the beaming process the first two sticks, being held in the hand before the reed, retain the leases which travel up from one end of the warp to the other by the winding of the threads. These two sticks finally become the lease-rods seen in the loom.

The rest of the sticks are drawn out of the warp as they approach the first two sticks.

The English process of beaming is performed on the Beaming Frame shown in Figure XIII in which A is the loom-beam and B the coarse open reed. A weighted lever l is attached to the warping frame. From the warping frame, the warp is taken and two rods inserted through its end leases. The warp is then passed between the dents of the coarse reed B and wrapped round the warp-beam A in the manner described above, by turning the handle attached to it. During the beaming process, the two rods being held in the hand retain the leases which travel up from one end of the warp to the other. These rods finally become the lease-rods in the loom. The beer leases and end-to-end leases are untied as they approach the lease-rods. The weighted lever l maintains a slight tension in the warp so that it might build hard upon the beam. Without this weighted lever in the warping frame, the warp would wind round the beam loosely with the result that during the weaving operation, owing to the strain in the warp, the threads on the surface would sink in the beam and either break or get entangled. A beaming frame of the above type has been constructed by Messrs. Geo. Hattersley & Sons.

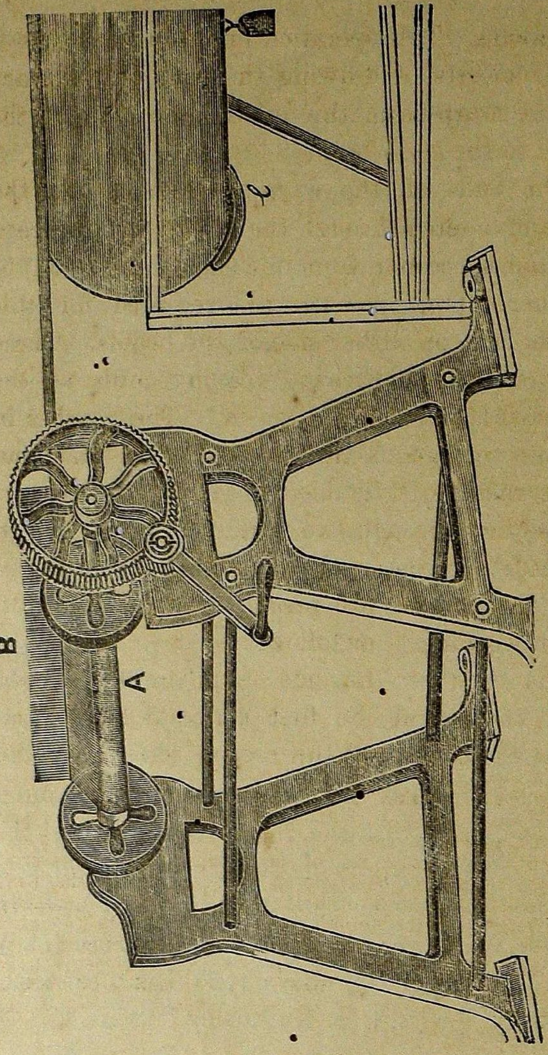


Figure XIII.—The Beaming Frame.

Drawing. This operation known also as 'drawing-in' consists of drawing the ends of the warp from the warp-beam through the healds and the reed on to the cloth-beam.

The ends of the warp are taken from the beam and entered through the healds and the reed in regular succession from one end of the beam to the other. Two operators are required for this purpose, one on either side of the healds. These operators are known in weaving mills as the 'reacher-in' and the 'drawer-in.' The reacher-in takes two contiguous threads from the warp and reaches them to a double hook which the drawer-in draws first through two healds and then through one space* in the reed. The draft or order in which the threads are passed through the healds, in plain weaving, is as follows:—

The ends of the odd numbers are drawn *through* the eyes of the first series of healds and *between* the healds of the second series; and the

* Writers on weaving vary with reference to the terms used to signify the small vertical strips (of steel or bamboo) of which a reed is composed and the spaces between them. The word 'dent' is used by some writers to mean one of these strips and by others one of these spaces, probably as the origin of it may either be the Latin word '*dens*' meaning 'a tooth' or the Anglo-Saxon word '*dynt*' meaning 'a blow' from which the English word 'dent' meaning 'a cavity made by a blow' is derived. As these spaces are formed not by incisions made in the reed during its manufacture but as the result of strips placed at intervals, the word 'dent' is used in this book to signify a 'strip' or 'tooth' and the word 'space' to denote the 'opening' between two teeth.

ends of the even numbers are drawn *between* the healds of the first series and *through* the eyes of the second series of healds. Thus the two shafts of healds contain the alternate threads of the warp.

The order in which the threads are entered through the reed in plain weaving is two contiguous threads through each space. The operators have to be very careful and to see that the threads do not cross or get entangled. Having passed the threads of the warp through the reed, they are finally fixed on to the cloth-beam and wrapped round it two or three times. The fixing on the cloth-beam is done by putting the ends of the threads into a channel cut along the side of the beam and then inserting a long narrow batten over them. The threads are similarly fixed on to the warp-beam.

Certain Indian weavers avoid the drawing-in process in the following manner. During the operation of beaming they use the loom reed instead of a coarse open reed to pass the warp threads through, which are entered in the same order as in the drawing process. When the beaming is done, the ends of the warp are fixed on to the cloth-beam. The weavers now raise a complete ~~series~~ of healds between the reed and the warp-
set

beam. The replacing of healds, the loops of which wear out after about a dozen pairs of *dhooties* are woven, is also thereby effected. This passing of the warp through the loom reed in the beaming process and the formation of healds on the loom are reckoned by these weavers (who are adept in heald-making) to be less laborious than the passing of the warp through the coarse open reed and the drawing-in process.

Twisting. A repetition of the drawing-in process for separate pieces of warp is obviated by a simple device if the same web is to be continued. After a warp is woven its extremity is kept filled in the reed and the healds. This portion is then cut off from the cloth-beam and the warp-beam and knotted at opposite ends to prevent it from coming out of the healds and the reed. When a new warp is to be drawn in, its ends have merely to be twisted to the old ends and carefully pulled through the healds and the reed. As drawing-in is a slow and tedious process, this device saves a deal of time and labour to the weaver.

It will appear to the reader from the contrivances mentioned above that certain economies may be effected in the practice of this craft. These devices are commended to the careful atten-

tion of the weaver as they may help to lessen his cost of production. Here also it may be observed that the wear at the centre of a heald being very great, English weavers use heald-mails made of steel or glass instead of loops made of silk, cotton or gut. These mails preserve their healds for a longer period than the loops made in this country and they may be tried here. It should however be stated that heald-mails generally increase the breakage in warp threads. The weaver, who is not a heald-maker, would therefore have to compare the cost of heald replacing with that of the labour in piecing broken threads.

CHAPTER VII.

The Improvement of Looms.

The inventive faculty of the Indian has laid dormant since the origin of spinning, weaving and architecture. During these many centuries he has not aroused himself to the need for industrial or mechanical development, but now that the necessity for invention is being greatly felt and his mind exercised over it, this faculty is likely to manifest itself. It is certainly desirable that the ingenious machinist should undertake this work, but if the development of the Indian loom has to be conducted on the lines of the English machine, no special talent would appear to be necessary. Patient and arduous toil however awaits the intending inventor. He has to study the construction of foreign looms, to learn the needs and resources of our weavers and then to experiment on his devices till he attains proper success. There will undoubtedly be many instances of mechanical failures such as are recorded in the Patent Offices in England but these must not discourage him. At the same time elaborate improvements should not be attempted, for the weaver must also be able to accept them. In the present languishing

state of the industry, it would be futile to introduce supplemental parts in looms with a view to obtaining a variety of fabrics, but improvements that would quicken the process of weaving should immediately be devised. The extraordinary skill that the Indian has exhibited in weaving fabrics of the utmost beauty and excellence has now to be diverted, owing to the exigencies of the age, to the rapid and economic construction of his textiles.

In the Indian Fly-Shuttle Loom, alterations and additions are possible that would make it almost as automatic a machine as the Japanese Loom, but this would at the same time place it beyond the reach of the weaver in this country. It must be realised that in his sunken condition his ability to outlay is small and improvements only on the most economic basis could be adopted by him. Some simple improvements are therefore suggested and looms constructed on such lines dealt with herein.

Of the three principal motions in a loom, the one that requires the greatest care and accuracy in working is the picking motion. If this could be combined in the Indian loom with one of the other motions a greater speed would be attained. As we have already seen, picking has been connected with beating-up in the Sayajee Cottage

Loom. These two motions have also been combined in Churchill's Loom. This loom has been constructed by Mr. D. C. Churchill of the Petit School of Industrial Arts at Ahmednagar and has been spoken of by Mr. Alfred Chatterton of Madras in his Government Report in the following terms. "By swinging the slay, the picking stick is set in motion through a series of levers and in such a manner that a very high speed of picking can be obtained. The slay can be easily worked with one hand and the shedding motion is controlled by pedal levers. An important feature in this loom is that from the warping beam, the warp passes over a roller mounted on spring bearings, whereby the action of beating up the weft has less tendency to injure a fragile warp. The loom is also provided with an automatic take-up motion of an ingenious character which can be readily adjusted for either close or open weaving. At the time of my visit to Ahmednagar a number of these looms were at work on *dungari* made from cotton of 10's counts both in warp and weft. So far his looms have only been worked on coarse counts." This loom appears to be still going through its period of trial but Mr. Chatterton expects that it will prove an acquisition to handweavers. He says that it can be constructed at a cost of Rs 60 only.

An important feature in the process of weaving which should here be observed, is that the picking motion is really an adjunct of the shedding motion, that is, the former follows the latter so quickly being intimately connected with its result that the two may be regarded as a continuous motion. This is not the case with beating-up which is not so closely joined with any other motion. For this reason, if two motions have to be connected, a combination of shedding and picking would undoubtedly be more appropriate than any other combination of two motions in the loom. Moreover, in a loom where the taking-up motion is not automatic, the action of beating-up should be kept distinct and reserved entirely for the working of one hand as it must regulate the texture of the cloth. Furthermore, the Indian weaver is so accustomed to this method that any change in it would not be readily acceptable to him. Shedding and picking being conjoined could be better worked from the same source—namely, the action of the treadles—leaving the hand free to beat up the weft. This would, in fact, ensure greater accuracy than under the existing system of working the feet for the one and the hand for the other, when both form practically the same movement. The Simplex Automatic Loom is an instance of a

machine combining these two motions, as we have seen before.

Every proper loom should have a back-rail mounted on springs or rubber cushions. This back-rail yielding at every strain lessens any undue tension on the warp during the process of weaving and thereby prevents the weak threads from giving way. Certain English looms have an oscillating back-rail which serves the same purpose. This rail becomes almost indispensable when long warps are used, for without it the threads very often get embedded in the warp if a proper tension is maintained.

In the Japanese Loom an improvement would save a certain amount of time and trouble to its worker. It sometimes happens that the shuttle, owing to irregular picking or shedding, gets trapped in the closing shed and breaks up a whole row of warp threads as the slay advances. To prevent this breakage, English looms usually have a 'loose reed' which draws back by the pressure of the shuttle against it, thus relieving the tension on the warp. The reed closes again when the shuttle is taken out. The reed in the Japanese Loom should also be similarly constructed and set. A loose reed may not be firm enough to stand the hard beating employed in heavy fabrics, but such fabrics are

not usually woven; and if work of this nature is undertaken a fast and loose reed could be used. The breakage just referred to does not occur in the Indian loom, for the beating-up motion remaining distinct from the other motions and being effected by the hand, the slay is instantly stopped when the shuttle gets caught in the shed.

In using long warps another improvement is necessary in looms which have both an automatic take-up and beating-up motions like the Japanese Loom. As the quantity of cloth wound on the cloth-beam goes on increasing its diameter also continues to enlarge, with the result that a larger and larger quantity of cloth begins to be taken up at every movement of the take-up wheel and the weaving becomes more and more bare. To counteract this effect, a friction-roller should be introduced as in the power-loom. This roller is placed over and in contact with the beam by means of a weighted lever below and being turned by the take-up wheel one tooth at a time, imparts this equal pacing motion to the cloth-beam no matter how much its diameter may vary. This difficulty of unequal weft placing would not arise unless a loom had both an automatic take-up and beating motions, for if the former action were irregular, the latter if effected by the hand could counteract it.

CHAPTER VIII.

Calculations in Weaving.

Yarn Measure.

1 Skein or Lea of Yarn = 120 yards.

1 Hank of yarn = 840 yards or 7 skeins.

Yarn Number. In No. 1 counts, 1 hank of yarn weighs 7000 grains* or 1 pound, that is—

If 1 lb. of yarn contains 1 hank, the counts of the yarn is 1s,

and if 1 lb. of yarn contains 40 hanks, the counts of the yarn is 40s,

and if 1 lb. of yarn contains 60 hanks, the counts of the yarn is 60s,

and so on;

∴ *Counts represent the number of hanks to the pound.* Yarn is numbered from 1 to 200 usually which are from the thickest to the thinnest thread. To understand the system clearly, it must be realised that if the weight and length of the yarn remain the same (i.e., 1 lb. and 840 yds.) but thinner threads are spun out of it, the number of hanks will increase. Therefore, the finer the yarn, the

* In cotton mills, a table composed of Troy and Avoirdupois weights is used. This system is adopted to ensure perfect accuracy in small weighments.

greater will be the number of hanks, that is, the higher the number of the counts.

Having weighed a certain length of yarn it will now be possible to tell of what counts it is.

If 1 skein of yarn weighs 32 grains, of what counts will be the yarn? 840 yards weigh 7000 grains in No. 1 counts, ∴ 120 yards should weigh 1000 grains in No. 1 counts, but when it weighs only 32 grains, it is evident that the yarn is much finer and the counts higher or that it is in the proportion of 1000 to 32 or 31·25 to 1=31·25s counts, it being understood that this enumeration is based on the standard of No. 1 counts.

If 5 skeins of yarn weigh $66\frac{2}{3}$ grains, of what counts will be the yarn? 840 yards weigh 7000 grains in No. 1 counts, ∴ 5 skeins or 600 yards should weigh 5000 grains in No. 1 counts. Divide 5000 by $66\frac{2}{3}$ and the quotient will be the counts. $\frac{5000}{\frac{200}{3}} = \frac{15000}{200} = 75$s counts.

The above calculations may also be obtained by double rule of three thus:

If 5000 grs. are contained in 600 yds. in No. 1 counts,

1 gr. is " " $\frac{600}{5000}$ yds. "

and $66\frac{2}{3}$ grs. are " " $\frac{200}{3} \times \frac{600}{5000}$ or 8 yds. "

In 8 yds. the counts is 1s if it weighs $66\frac{2}{3}$ grs.
$\therefore$ in 1 yd. „ „ $\frac{1}{8}$s „ „ „
and in 600 yds. „ „ $\frac{600}{8}$ or 75s „ „
= 75s counts.

Contraction in Cotton Cloth. The width contraction varies from 2″ to $2\frac{1}{4}$″, that is, the warp stands so much wider in the reed than in the cloth. Therefore, a loom must always have a reedspace at least 2″ more than the width of the cloth required to be woven in it. Thus a loom with 30″ reedspace will weave cloth of 28″ width, one with 42″ reedspace cloth of 40″ width and one with 50″ reedspace cloth of 48″ width. The contraction in the length of a piece is about 1 yard in 20 yards, and varies with the number of picks put in and the counts of the weft used. The contraction in cotton cloth is therefore approximately 5 per cent. in the width as well as in the length.

Wastage in Weaving. The waste in yarn should not be more than 2 per cent. for warp and 5 per cent. for weft. It is heavier in the latter owing to the greater piecing necessary in the weft due to the small length contained in each pirn.

To find the quantity of yarn required for a piece of cloth.

1. *Count the warp threads in the cloth.* If 40 to the inch allow 5 per cent. for contraction, $\therefore$ 38

threads to the inch would produce the required effect. If 44″ width be required, allowing about 5 per cent. for contraction, 46″ of the reed would have to be filled with warp, ∴ the number of warp ends would be $38 \times 46 = 1748$. Say, length of cloth required be 100 yards, allowing 5 per cent. for contraction, the length of warp to be put into the loom would be 105 yds. Therefore warp required would be 105 yards $\times 1748 = 183{,}540$ yds. or $\frac{183{,}540}{840} = 218\frac{1}{2}$ hanks. Add for waste about 2 per cent. $= 223$ hanks. If the counts used be 40s, dividing by $40 = 5\frac{23}{40}$ lbs.

2. *Count the weft threads in the cloth.* If 45 to the inch, allow about 5 per cent. for contraction, ∴ 43 threads to the inch would produce the required effect. (This would require 43 picks to the inch.) If 44″ width be required, allowing about 5 per cent. for contraction, 46″ of weft would be used in every pick, ∴ the length of weft threads per inch of cloth filled would be $43 \times 46''$. If length of cloth required be 100 yards, allowing 5 per cent. for contraction the length of weft necessary for 105 yards would be

$$\frac{43 \times 46 \times 105 \times 36}{36} \text{ yds.} = \frac{43 \times 46 \times 105}{840} = 247\tfrac{1}{4} \text{ hanks.}$$

Add for waste about 5 per cent. $= 260$ hanks. If the counts used be 50s, dividing by $50 = 5\frac{1}{5}$ lbs.

Therefore, yarn required for warp and weft would be $5\frac{23}{40}$ lbs. + $5\frac{8}{40}$ lbs. = $10\frac{31}{40}$ lbs.

If a Dhooty 44″ × 5yds. in size be required to be woven of 40s and 50s yarn, the aforesaid quantity would suffice for 10 pairs.

Borders. Threads used for borders are always thicker than threads used for the body of the cloth. These stronger threads are required to resist the greater wear at the edges of the fabric. If 40s and 50s yarn be used for the body, 20s or 30s twist would be required for borders; and if 60s and 70s yarn be used for the former, 40s or 50s twist would be required for the latter. But if lower counts are not at hand, the same counts may be used for borders as for the body, provided double threads are used in the borders, that is, four contiguous threads passed through each space of the reed and two through each eye of heald. Threefold threads are also sometimes used for borders.

Outturn. The outturn of a loom is rated by the number of times it picks per minute. This, of course, depends on the condition of the warp and the capacity of the weaver. If the warp has not been properly sized and dressed, it will not stand the strain and friction on the loom. There will be breakage in the warp threads to mend which will require time. If the weaver has not

been able to beam the warp properly or has not set the parts of the loom correctly, there will be difficulty and frequent stoppages, owing to which the weaving operation will be slow. As the outturn depends on the number of picks per minute, in fine cloth, where more weft threads are put in to the inch, weaving is slower than in coarse cloth where a smaller number of weft threads are required to fill the same space. A narrow loom, in which the shuttle has to travel a small distance for each pick, works faster than a broad loom.

CHAPTER IX.

ESTIMATES.

Before giving estimates which would be useful to intending weavers, a word may be said regarding the employment of looms as enquiries are often made by these people as to the type of machine they should select. Looms like all other machines are constructed to suit different requirements. For instance, the Jacquard machine is meant to prepare the most intricate patterns in fancy weaving, Bullough's common loom is perhaps the best machine for plain weaving and the Dobby apparatus, a modification of the Jacquard harness, is used in East Lancashire for the figured borders of Indian Saries. But the Indian hand weaver has a very limited choice in the matter of his looms. All the types at present available in this country—the Fly-Shuttle, the Simplex Automatic and the Japanese looms are meant only for plain weaving. The Fly-Shuttle has been utilised for weaving cloths of the highest counts of yarn, the Simplex for cloths up to 120s counts and the Japanese loom for cloths up to 40s counts. The largest quantity, however, of cloth consumed in India being of plain webs, the present needs of

the country can almost entirely be supplied by the aforesaid looms. Approximate estimates for setting up and working the Simplex and Japanese looms are given below. Either of these looms with a hand-warping machine would ensure a higher profit to the weaver than that olltained by the Fly-Shuttle loom with the existing systems of warping.

Estimate 1.

Outlay—1 Simplex Automatic Loom complete with healds, reed and shuttle ... ... Rs. 60

1 Hand-Warping Machine complete with creel and heck ... ... Rs. 55

2 Charkas, 6 Charkis (large and small). 6 Natais, a Coarse Reed, 300 Bobbins and Pirns, etc. ... ... Rs. 10

Capital for Yarn and Sundries... ... ... Rs. 25

Total Outlay ... Rs. 150

Outturn of 1 Simplex Loom on 40s yarn per day of 8 working hours = 9 yards, and per month of 22 weaving days = 198 yards of cloth.

Cost of 40s yarn $21\frac{1}{2}$ lbs. (for 198 yds.) @ -/11/-* ⅌ lb. Rs. 14/12

Replacing of healds ... ... Rs. 3/-

Repairs and sundries ... ... Re. 1/-

Total Cost ... Rs. 18/12

Sale of 198 yards or $19\frac{4}{5}$ pairs of Dhuties @ 2/8† per pair ... ... Rs. 49/8

Less Total Cost ... Rs. 18/12

Nett Profit per month ... Rs. 30/12

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* This is the average price of 40s yarn at present in Calcutta which is selling @ Rs. 2/13 to 4/1 per bundle of 5 lbs.

† This is the average price of Bengal hand-loom dhuties of 40s counts, 44″ × 5yds. which are now selling in Calcutta @ Rs. 2/4 to 2/12 per pair.

Preparing the above yarn would mean a labour of about 60 hours for the weaver and a member of his family—30 hours for sizing, 18 hours for winding and 12 hours for warping. Looming the yarn would require about 12 hours' work from them.

ESTIMATE 2.

Outlay—1 Japanese Loom complete with healds, reed and shuttle	Rs. 150
1 Hand-Warping Machine (complete)... ...	Rs. 55
2 Charkas, 8 Charkis (large and small) 8 Natais, a Coarse Reed, 400 Bobbins and Pirns, etc.	Rs. 12
Capital for Yarn and Sundries...	Rs. 33
Total Outlay ...	Rs. 250

Outturn of 1 Japanese Loom on 40s yarn per day of 8 working hours=12 yards, and per month of 21 weaving days=252 yards of cloth.

Cost of 40s yarn 27¼ lbs. (for 252 yds.) @ -/11/- ₱ lb.	Rs. 18/12
Replacing of healds...	Rs. 4/-
Repairs and sundries	Re. 1/4
Total Cost ...	Rs. 24/-

Sale of 252 yards or 25½ pairs of Dhuties @ 2/8 per pair	Rs. 63
Less Total Cost ...	Rs. 24
Nett Profit per month ...	Rs. 39

Preparing the above yarn would mean a labour of about 73 hours for the weaver and a member of his family—37 hours for sizing, 22 hours for winding and 14 hours for warping. Looming the yarn would require about 14 hours' work from them.

Estimate 3.

Outlay—5 Japanese Looms (complete)	... Rs. 750
1 Hand-Warping Machine (complete)	... Rs. 55
1 Bobbin- and 1 Pirn-Winder, 20 Swifts with stands, 1000 Bobbins and Pirns, etc.	... Rs. 150
1 Beaming Frame	... Rs. 80
Capital for yarn, labour and sundries	... Rs. 315
Total Outlay ...	Rs. 1350

Outturn of 5 Japanese Looms on 40s yarn per day of 8 working hours = 60 yards, and per month of 26 weaving days = 1560 yards of cloth.

Cost of 40s yarn 168 lbs. (for 1560 yds.) @ -11/- ⅌ lb.	... Rs. 115/8
Labour of weaving 1560 yds. @ 1a. ⅌ yd. 40 picks to the inch	... Rs. 97/8
(Weaving 12 yds. ⅌ day on the Japanese loom, the weaver would earn 12 as. each day.)	
Labour of single sizing, machine winding and warping @ 3 as. ⅌ lb. for 40s warp, and of machine winding only @ 1a. ⅌ lb. for 40s weft, *i.e.* @ an average of 2 as. ⅌ lb. for preparing 40s yarn, for 168 lbs.	... Rs. 21/-
Labour of machine beaming and of drawing-in 1638 yds. of warp with 1748 ends @ $\frac{3}{4}$ a. ⅌ 10 yds.	... Rs. 7/11
Replacing of healds, reed and shuttle ...	... Rs. 22/
Sizing ingredients	... Rs. 3/-
Rent, repairs and sundries	... Rs. 18/-
Total Cost ...	Rs. 285/11

Sale of 1560 yds. or 156 pairs of Dhuties @ Rs. 2/8 ⅌ pair	... Rs. 390/-
Less Total Cost ...	Rs. 285/11
Nett Profit per month ...	Rs. 104/5

In hand-loom factories, the operatives would have to be paid not by a monthly wage but according to the work done. The weaver class might not be agreeable to this arrangement but the poorer recruits in the industry would, and these people would have to be employed. It will be seen that the rates allowed in Estimate 3 for weaving, yarn preparing and looming amount to about 13 as. per pair of dhooties (10 yds.) which is nearly as high as the rate charged by weavers, yarn preparers and loomers that work by contract at present. These labourers, however, cannot earn more than 7 or 8 as. a day, their methods being very slow. Even those working on their own account do not earn more, if a deduction be made for the labour of their assistants. But working on the improved methods alluded to in this estimate, these labourers would earn about 12 as. a day, as their outturn would be greater. If these conditions were explained to them, there would be no difficulty in securing operatives at the aforesaid rates.

LOOMS AND WEAVER'S MACHINES.	PRICE.	WHERE OBTAINABLE:
The Indian Fly-Shuttle Loom ...	42" reedspace Rs. 45 46" ,, ,, 50	Messrs. P. N. De, Hem Sosi Shome and Sotish Chunder Ghosh of Chinsurah; B. K. Ghose of Chandernagore; and from Serampore Weavers.
The Madras Frame Loom ...	36" ,, ,, 75 54" ,, ,, 100	The Weaving Department of the Government School of Arts, Madras.
The Sayaji Cottage Attachment introduced by R. B. Patel Esq. Director of Industries and Agriculture, Baroda.	Rs. 15	The Director of Industries and Agriculture, Baroda.
The Simplex Automatic Loom invented by Mr. C. L. Agarwallah of Jorasanko, Calcutta	46" ,, ,, 60	The Palli Silpa Sala, 4 Modun Mohun Chatterjee's Lane, Jorasanko, Calcutta.
The Japanese Loom	36" ,, ,, 120 42" ,, ,, 140 46" ,, ,, 150 50" ,, ,, 170	Messrs. Khetter Mohun Dey & Co., 45 Radha Bazar Street, Calcutta.

APPENDIX.—(*Continued.*)

Looms and Weaver's Machines.	Price.	Where obtainable.
The Japan Hand Loom ...	36″ „ Rs. 120 45″ „ „ 130 54″ „ „ 150	The Manager, Loom Manufacturing Company, Ludhiana.
Hand-Warping Machine ... Beaming Frame	36″ diam. of reel „ 55 48″ width „ 80	The Secretary of the Palli Silpa Sala has agreed to construct these machines.
Bobbin-Winder	Winding 4 bobbins together Rs. 25	Khitlish Chunder Chakravarti, 8 Balakhana Street, Calcutta.
Hattersley's		
Warping Mill and Creel with Runner or lease-taker	3 metres in circumference Rs. 220	Messrs. Shaw Wallace & Co., Strand Road, Calcutta.
Beaming Frame	Rs. 140	Do. Do.
Pirn Winder	3 Spindle „ 50	Do. Do.
Bobbin Winder	4 Spindle 50	Do. Do.

Trained weavers may be obtained by applying to the National Weaving School, Cornwallis Street, Calcutta.

ERRATA.

In page 8 line 18, *for* since *read* always.

Do. 51 „ 15 „ about „ quite.

Do. 94 last line „ series „ set.